

Assignment 6

Consider 6.0 g of helium at 40°C in the form of a cube 40 cm. on each side. Suppose 2000

J of energy are transferred to this gas.

- Determine the final pressure if the process is at constant volume.
- What is the final volume if instead the process is at constant pressure?
- On a single pV diagram, show and label both processes.

17.54. Model: The process in part (a) is isochoric and the process in part (b) is isobaric.

Solve: (a) Initially $V_1 = (0.20 \text{ m})^3 = 0.0080 \text{ m}^3 = 8.0 \text{ L}$ and $T_1 = 293 \text{ K}$. Helium has an atomic mass number $A = 4$, so 3 g of helium is $n = M/M_{\text{mol}} = 0.75$ mole of helium. We can find the initial pressure from the ideal-gas law:

$$p_1 = \frac{nRT_1}{V_1} = \frac{(0.75 \text{ mol})(8.31 \text{ J/mol K})(293 \text{ K})}{0.0080 \text{ m}^3} = 228 \text{ kPa} = 2.25 \text{ atm}$$

Heating the gas will raise its temperature. A constant volume process has $Q = nC_v\Delta T$, so

$$\Delta T = \frac{Q}{nC_v} = \frac{1000 \text{ J}}{(0.75 \text{ mol})(12.5 \text{ J/mol K})} = 107 \text{ K}$$

This raises the final temperature to $T_2 = T_1 + \Delta T = 400 \text{ K}$. Because the process is isochoric,

$$\frac{p_2}{T_2} = \frac{p_1}{T_1} \Rightarrow p_2 = \frac{T_2}{T_1} p_1 = \frac{400 \text{ K}}{293 \text{ K}} (2.25 \text{ atm}) = 3.07 \text{ atm}$$

(b) The initial conditions are the same as part a, but now $Q = nC_p\Delta T$. Thus,

$$\Delta T = \frac{Q}{nC_p} = \frac{1000 \text{ J}}{(0.75 \text{ mol})(20.8 \text{ J/mol K})} = 64.1 \text{ K}$$

Now the final temperature is $T_2 = T_1 + \Delta T = 357 \text{ K}$. Because the process is isobaric,

$$\frac{V_2}{T_2} = \frac{V_1}{T_1} \Rightarrow V_2 = \frac{T_2}{T_1} V_1 = \frac{357 \text{ K}}{293 \text{ K}} (0.0080 \text{ m}^3) = 0.00975 \text{ m}^3 = 9.75 \text{ L}$$

(c)

PSS 17.1: The Bermuda Triangle

Description: Find the work done on an ideal gas in a simple isochoric-isobaric-constant pV process. (PSS 17.1: Work in ideal-gas processes)

Learning Goal: To practice Problem-Solving Strategy 17.1 for problems involving calculating work done on an ideal gas.

A cylinder with initial volume V contains a sample of gas at pressure P . The gas is heated in such a way that its pressure is directly proportional to its volume. After the gas reaches the volume $3V$ and pressure $3P$, it is cooled isobarically to its original

volume V . The gas is then cooled isochorically until it returns to the original volume and pressure.

Find the work W done on the gas during the entire process.

MODEL: Assume that the gas is ideal and the process is quasi-static.

VISUALIZE: Show the process on a pV diagram. Note whether it happens to be one of the basic gas processes: isochoric, isobaric, or isothermal.

SOLVE: Calculate the work as the area under the pV curve either geometrically or by carrying out the integration:

$$\text{work done on the gas } W = -(\text{area under } pV \text{ curve}) = - \int p dV$$

ASSESS: Check your signs.

- $W > 0$ when the gas is compressed. Energy is transferred from the environment to the gas.
- $W < 0$ when the gas expands. Energy is transferred from the gas to the environment.
- No work is done if the volume doesn't change: $W = 0$.

Model

Start by making simplifying assumptions appropriate for the situation.

Part A

It is reasonable to use the *ideal-gas* model in this problem if which of the following conditions are met?

Check all that apply.

- ANSWER:**
- The temperature is well below the condensation point.
 - The temperature is well above the condensation point.
 - The density of the gas is low.
 - The density of the gas is high.
 - The pressure of the gas is much greater than atmospheric pressure.
 - The pressure of the gas is much smaller than atmospheric pressure.

Part B

The processes involved can be assumed to be quasi-static if which of the following holds?

- ANSWER:** They happen slowly.
 They occur at low enough pressure.
 They occur at low enough volume.
 They occur at high enough temperature.



Visualize

Now draw a pV diagram. Note that there are three separate processes that together form a "cycle" that returns the gas to its starting point on the diagram. Be sure to indicate the direction and type of each process on your diagram. Use your diagram to answer the following questions.



Part C

The work done on the gas during its expansion from volume V to volume $3V$ is

- ANSWER:** positive
 negative
 zero

During the expansion phase described in the problem introduction, volume increases and so does the pressure. The gas performs work on the environment; hence, the work done *on* the gas is negative. However, the gas must be absorbing heat in this process.



Part D

The work done on the gas during the isobaric process is

- ANSWER:** positive
 negative
 zero

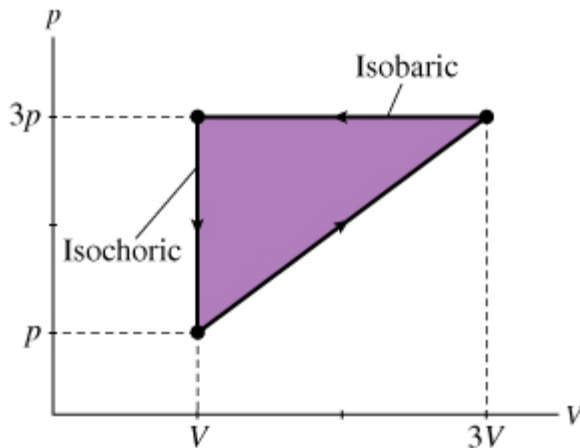


Part E

The work done on the gas during the isochoric process is

- ANSWER:** positive
 negative
 zero

Your pV diagram should look something like the figure shown here.



Solve

Now use the information and the insights that you have accumulated to construct the necessary mathematical expressions and to derive the solution.

Part F

Find the mathematical expression for the amount of work W done on the gas during the entire process.

Hint F.1 How to approach the problem

The value of the net work W done on the gas during the entire process equals the sum of the amounts of work done on the gas during each step of the process.

Part F.2 Find the work done during expansion from V to $3V$

Find W_e , the work done during expansion of the gas from volume V to volume $3V$.

Hint F.2.a How to compute the work

The absolute value of the work W_e done on the gas during the expansion equals the area under the curve (in our case, a segment of a straight line) corresponding to that process.

Express your answer in terms of p and V .

ANSWER: $W_e = -4pV$

Part F.3 Find the work done during isobaric compression

Find W_p , the work done on the gas during isobaric compression.

Hint F.3.a How to compute the work

The absolute value of the work W_p done on the gas during the isobaric process equals the area under the curve (in our case, a segment of a straight line) corresponding to that process.

Express your answer in terms of p and V .

ANSWER: $W_p = 6pV$

Express the work in terms of p and V .

ANSWER: $W = 2pV$

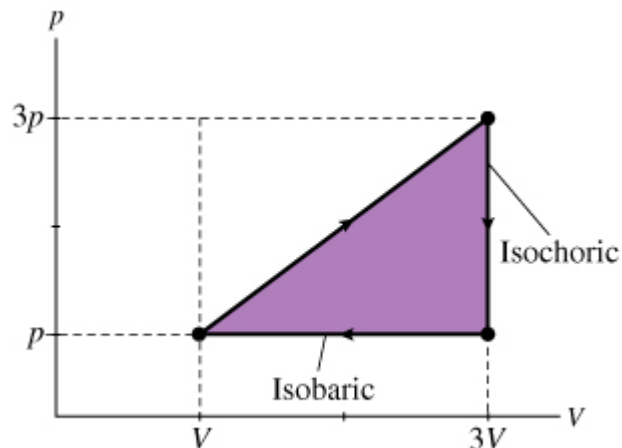
Note that the value of W equals, not surprisingly, the area A_{cycle} enclosed by the entire gas cycle as drawn on the pV diagram: $W = A_{\text{cycle}}$. If the direction of the process were reversed, the overall work would have been negative: $W = -A_{\text{cycle}}$.



Assess

When you work on a problem on your own, without the computer-provided feedback, only you can assess whether your answer seems right. The following question will help you practice the skills necessary for such an assessment.

Part G



If the gas cycle were reordered, so that the isochoric process came before the isobaric process, the work done on the gas during the entire new cycle would be

Hint G.1 How to approach this question

In the solve part of this problem, you determined mathematically that the work done on the gas was positive. However, you could also have predicted that result by noting that the expansion of the gas takes place at lower average pressure than its compression. Apply this same reasoning to predict the sign of the work in the

second process.

- ANSWER:** positive
 negative
 zero

This answer should make sense because the gas is compressed at a higher average pressure than that during the expansion process. Of course, it also agrees with the mathematical expression obtained before.

A Sliding Crate of Fruit

Description: For a crate of fruit sliding down an incline with friction, calculate the work done by the friction and the temperature change of the crate if all of the heat generated is absorbed by the crate.

A crate of fruit with a mass of 37.5 kg and a specific heat capacity of $3700 \text{ J/(kg} \cdot \text{K)}$ slides 8.10 m down a ramp inclined at an angle of 35.2 degrees below the horizontal.

Part A

If the crate was at rest at the top of the incline and has a speed of 2.85 m/s at the bottom, how much work W_f was done on the crate by friction?

Hint A.1 How to approach the problem

If no friction were acting, then the kinetic energy of the crate at the bottom of the incline would equal the difference in gravitational potential energy of the crate between its initial and final positions. The nonconservative (nc) frictional force is responsible for the difference. To find the work done by friction, apply energy conservation: $K_i + U_i + W_{nc} = K_f + U_f$.

Part A.2 Find the initial and final kinetic energies

What is the kinetic energy of the crate before it starts to slide (K_i) and after it reaches the bottom of the ramp (K_f)?

Express your answer in joules as two terms separated by commas.

ANSWER: $K_i, K_f = 0, \frac{mv^2}{2} \text{ J}$

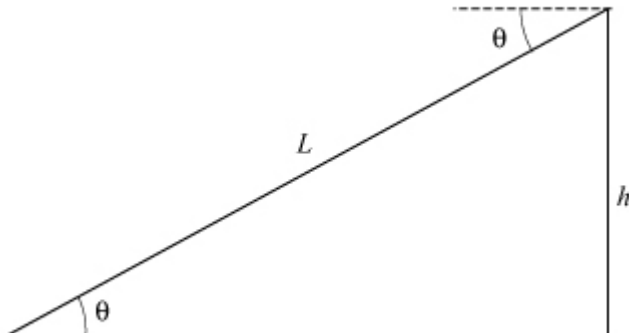
Part A.3 Find the difference between initial and final potential energy

What is $U_f - U_i$, the change in the potential energy of the crate from when it starts to slide to after it reaches the bottom of the ramp?

Part A.3.a A helpful formula and a helpful diagram

The difference in the potential energy of the crate is given by $U_f - U_i = -mgh$,

where h is the height shown in the figure below. What is the value of h ?



Express your answer in meters.

ANSWER: $h = L \sin(\theta)$ m

Express your answer in joules.

ANSWER: $U_f - U_i = -mgL \sin(\theta)$ J

Use 9.81 m/s^2 for the acceleration due to gravity and express your answer in joules.

ANSWER: $W_f = \frac{mg^2}{2} - (mgL \sin(\theta))$ J

The frictional force opposes the motion of the crate, so the work done on the crate by friction must be a negative quantity.

Part B

If an amount of heat equal to the magnitude of the work done by friction is absorbed by the crate of fruit and the fruit reaches a uniform final temperature, what is its temperature change ΔT ?

Hint B.1 Equation for temperature change

The quantity of heat needed to increase the temperature of an object by a certain amount is given by $Q = mc\Delta T$, where m is the object's mass, c is its specific heat, and ΔT is the temperature change (in kelvins) of the object. In this case Q is a positive quantity since the temperature of the crate is increasing.

ANSWER: $\Delta T = \frac{gL \sin(\theta)}{c} - \frac{v^2}{2c}$ °C

Of course, the assumptions of "total heat absorption" and "uniform temperature change" are not very realistic; still, this simplified model provides a useful reminder about the transformation of mechanical energy into thermal energy when nonconservative forces are present.

Melting Ice

Description: Ice, initially below freezing, is heated at a constant rate. Calculate the time elapsed before the ice starts to melt, and the time elapsed before the temperature rises above 0 degrees celcius.

An open container holds ice of mass 0.535 kg at a temperature of $-19.1 \text{ }^\circ\text{C}$. The mass of the container can be ignored. Heat is supplied to the container at the constant rate of 890 J/minute .

The specific heat of ice is $2100 \text{ J/kg}\cdot\text{K}$ and the heat of fusion for ice is $334 \times 10^3 \text{ J/kg}$.

Part A

How much time t_{melt} passes before the ice *starts* to melt?

Hint A.1 How to approach the problem

Calculate the heat needed to raise the temperature of the ice to its melting point, and use this to find the time elapsed given the heating rate.

Part A.2 Calculate the heat needed

Calculate the heat Q needed to raise the temperature of the ice to the melting point.

Hint A.2.a Equation for heat gain without phase change

Until the ice begins to melt at $0 \text{ }^\circ\text{C}$, the equation $Q = mc\Delta T$ can be used to calculate the heat added to the ice.

ANSWER: $Q = m \cdot 2100T \text{ J}$

ANSWER: $t_{\text{melt}} = \frac{m \cdot 2100T}{E} \text{ minutes}$

Part B

From the time when the heating begins, how much time t_{rise} does it take before the temperature begins to rise above $0 \text{ }^\circ\text{C}$?

Hint B.1 How to approach the problem

Calculate the heat needed to melt the ice and combine this with the rate that heat is

being added to the system to find the time it will take to melt the ice.

Part B.2 Calculate the time to melt the ice

Starting when the ice reaches 0°C , how much time t_{melt} is needed until the ice completely melts?

Hint B.2.a Heat needed to melt the ice

The heat needed to melt a mass $m = 0.535 \text{ kg}$ of a material is given by $Q = mL_f$, where L_f is the heat of fusion for the material.

ANSWER:
$$t_{\text{melt}} = \frac{m \cdot 334 \cdot 10^3}{H} \text{ minutes}$$

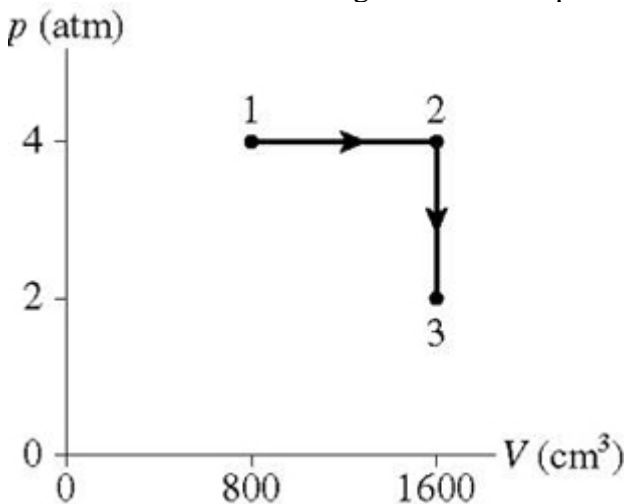
Remember that the question is asking for the time elapsed from when the *heating* first begins, not from the time the ice begins melting.

ANSWER:
$$t_{\text{rise}} = \frac{m \cdot 2100T}{H} + \frac{m \cdot 334 \cdot 10^3}{H} \text{ minutes}$$

Problem 17.61

Description: n of a monatomic gas follows the process shown in the figure. (a) How much heat energy is transferred to or from the gas during process 1 \rightarrow 2? (b) How much heat energy is transferred to or from the gas during process 2 \rightarrow 3? (c)...

0.120 mol of a monatomic gas follows the process shown in the figure



Part A

How much heat energy is transferred to or from the gas during process $1 \rightarrow 2$?

ANSWER: $(4.1013 \times 10^5) (8 \times 10^{-4}) \frac{5}{2} \text{ J}$

Part B

How much heat energy is transferred to or from the gas during process 2 → 3?

ANSWER: $-(2.1013 \times 10^5) (1.6 \times 10^{-3}) \frac{3}{2}$
 $(2.1013 \times 10^5) (1.6 \times 10^{-3}) \frac{3}{2} \text{ J}$

Part C

What is the total change in thermal energy of the gas?

ANSWER: 0 J

17.61. Model: The monatomic gas is an ideal gas which is subject to isobaric and isochoric processes.
Visualize: Please refer to Figure P17.61.
Solve: (a) For this isobaric process, $p_1 = 4.0 \text{ atm}$, $V_1 = 800 \times 10^{-6} \text{ m}^3$, $p_2 = 4.0 \text{ atm}$, and $V_2 = 1600 \times 10^{-6} \text{ m}^3$. The temperature T_1 of the gas is obtained from the ideal-gas equation as:

$$T_1 = \frac{p_1 V_1}{nR} = 390 \text{ K}$$

where $n = 0.10 \text{ mol}$. Also,

$$T_2 = T_1 \frac{V_2}{V_1} = T_1 \left(\frac{1600 \times 10^{-6} \text{ m}^3}{800 \times 10^{-6} \text{ m}^3} \right) = 2T_1 = 780 \text{ K}$$

Thus, the heat required for the process 1 → 2 is

$$Q = nC_p(T_2 - T_1) = (0.10 \text{ mol})(29.1 \text{ J/mol K})(390 \text{ K}) = 1135 \text{ J}$$

This is heat transferred to the gas.
 (b) For the isochoric process, $V_2 = V_3 = 1600 \times 10^{-6} \text{ m}^3$, $p_2 = 4.0 \text{ atm}$, $p_3 = 2.0 \text{ atm}$, and $T_2 = 780 \text{ K}$. T_3 can be obtained from the ideal-gas equation as follows:

$$\frac{p_2 V_2}{T_2} = \frac{p_3 V_3}{T_3} \Rightarrow T_3 = T_2 (p_3 / p_2) = (780 \text{ K}) \left(\frac{2.0 \text{ atm}}{4.0 \text{ atm}} \right) = 390 \text{ K}$$

The heat required for the process 2 → 3 is

$$Q = nC_v(T_3 - T_2) = (0.10 \text{ mol})(20.8 \text{ J/mol K})(390 \text{ K} - 780 \text{ K}) = -811 \text{ J}$$

Because of the negative sign, this is the amount of heat removed from the gas.
 (c) The change in the thermal energy of the gas is

$$\Delta E_{\text{th}} = (Q_{1 \rightarrow 2} + Q_{2 \rightarrow 3}) + (W_{1 \rightarrow 2} + W_{2 \rightarrow 3}) = 1135 \text{ J} - 811 \text{ J} + W_{1 \rightarrow 2} + 0 \text{ J} = 324 \text{ J} - p\Delta V$$

$$= 324 \text{ J} - (4.0 \times 1.013 \times 10^5 \text{ Pa})(1600 \times 10^{-6} \text{ m}^3 - 800 \times 10^{-6} \text{ m}^3) = 0 \text{ J}$$

Assess: This result was expected since $T_3 = T_1$.

Problem 17.29

Description: A gas cylinder holds n of O_2 at T and a pressure of p . The gas expands adiabatically until the volume is doubled. What are the final (a) pressure and (b) temperature? (a) ... (b) ...

A gas cylinder holds 0.380 mol of O_2 at 180 °C and a pressure of 3.20 atm. The gas

expands adiabatically until the volume is doubled. What are the final (a) pressure and (b) temperature?

Part A

ANSWER: $P \left(\frac{1}{2}\right)^{1.40}$ atm

Part B

ANSWER: $T \left(\frac{1}{2}\right)^{1.40} = 2 - 273 \text{ } ^\circ\text{C}$

17.29. Model: The O_2 gas has $\gamma = 1.40$ and is an ideal gas.
Solve: (a) For an adiabatic process, pV^γ remains a constant. That is,

$$p_1 V_1^\gamma = p_f V_f^\gamma \Rightarrow p_f = p_1 \left(\frac{V_1}{V_f}\right)^\gamma = (3.0 \text{ atm}) \left(\frac{V_1}{2V_1}\right)^{1.40} = (3.0 \text{ atm}) \left(\frac{1}{2}\right)^{1.40} = 1.14 \text{ atm}$$

(b) Using the ideal-gas law, the final temperature of the gas is calculated as follows:

$$\frac{p_1 V_1}{T_1} = \frac{p_f V_f}{T_f} \Rightarrow T_f = T_1 \frac{p_f V_f}{p_1 V_1} = (423 \text{ K}) \left(\frac{1.14 \text{ atm}}{3.0 \text{ atm}}\right) \left(\frac{2V_1}{V_1}\right) = 321.5 \text{ K} = 48.5^\circ\text{C}$$

Problem 17.27

Description: A container holds m of oxygen at a pressure of p . (a) How much heat is required to increase the temperature by T at constant pressure? (b) How much will the temperature increase if this amount of heat energy is transferred to the gas at constant...

A container holds 1.30 m of oxygen at a pressure of 9.00 atm .

Part A

How much heat is required to increase the temperature by $120 \text{ } ^\circ\text{C}$ at constant pressure?

ANSWER: $\frac{m}{32} \cdot 29.2T \text{ J}$

Part B

How much will the temperature increase if this amount of heat energy is transferred to the gas at constant volume?

ANSWER: $\frac{29.2T}{20.9} \text{ } ^\circ\text{C}$

17.27. Model: The heating processes are isobaric and isochoric. O_2 is a diatomic ideal gas.
Solve: (a) The number of moles of oxygen is

$$n = \frac{M}{M_{\text{mol}}} = \frac{1.0 \text{ g}}{32 \text{ g/mol}} = 0.03125 \text{ mol}$$

For the isobaric process,

$$Q = nC_p\Delta T = (0.03125 \text{ mol})(29.2 \text{ J/mol K})(100^\circ\text{C}) = 91.2 \text{ J}$$

(b) For the isochoric process,

$$Q = nC_v\Delta T = 91.2 \text{ J} = (0.03125 \text{ mol})(20.9 \text{ J/mol K})\Delta T \Rightarrow \Delta T = 140^\circ\text{C}$$

Problem 17.37

Description: m_1 of aluminum at 200 degree(s) C and m_2 of copper are dropped into V of ethyl alcohol at 15 degree(s) C. The temperature quickly comes to T_2 . (a) What was the initial temperature of the copper?

12.0 g of aluminum at 200°C and 19.0 g of copper are dropped into 55.0 cm^3 of ethyl alcohol at 15°C . The temperature quickly comes to 28.0°C .

Part A

What was the initial temperature of the copper?

ANSWER:
$$\frac{m_1 c_{\text{Al}} (T_2 - 473) + m_2 c_{\text{Cu}} (T_2 - 288)}{m_2 c_{\text{Cu}}} + T_2 - 273 \text{ } ^\circ\text{C}$$

17.37. Model: There are three interacting systems: aluminum, copper, and ethyl alcohol.
Solve: The aluminum, copper, and alcohol form a closed system, so $Q = Q_{\text{Al}} + Q_{\text{Cu}} + Q_{\text{eth}} = 0 \text{ J}$. The mass of the alcohol is

$$M_{\text{eth}} = \rho V = (790 \text{ kg/m}^3)(50 \times 10^{-6} \text{ m}^3) = 0.0395 \text{ kg}$$

Expressed in terms of specific heats and using the fact that $\Delta T = T_f - T_i$, the $Q = 0 \text{ J}$ condition is

$$M_{\text{Al}} c_{\text{Al}} \Delta T_{\text{Al}} + M_{\text{Cu}} c_{\text{Cu}} \Delta T_{\text{Cu}} + M_{\text{eth}} c_{\text{eth}} \Delta T_{\text{eth}} = 0 \text{ J}$$

Substituting into this expression,

$$\begin{aligned} (0.010 \text{ kg})(900 \text{ J/kg K})(298 \text{ K} - 473 \text{ K}) + (0.020 \text{ kg})(385 \text{ J/kg K})(298 \text{ K} - T) \\ + (0.0395 \text{ kg})(2400 \text{ J/kg K})(298 \text{ K} - 288 \text{ K}) = -1575 \text{ J} + (7.7 \text{ J/K})(298 - T) + 948 \text{ J} = 0 \text{ J} \\ \Rightarrow T = 216.6 \text{ K} = -56.4^\circ\text{C} \end{aligned}$$

Two Conventions, One Law

Description: Several conceptual and computational questions focusing on relationships between U , Q and W . Questions emphasize that W , depending on the convention used by the problem authors, may mean either work done on or by the system.

Learning Goal: To understand the first law of thermodynamics, written using either "work done *on* the system" or "work done *by* the system."

is called *heat*. Heat transfer is very common in various processes, and it is important to extend the law of conservation of energy to those processes that involve not just mechanical *work* but also heat. Such an "extended" version of the law of conservation of energy is known as the **first law of thermodynamics**, and it can be expressed as

$$\Delta E_{\text{sys}} = \Delta E_{\text{mech}} + \Delta E_{\text{th}} = Q + W$$

where ΔE_{sys} is the change in the system's *total* energy, which is the sum of the change in the system's *mechanical* energy, ΔE_{mech} , and the change in the system's *internal* energy, ΔE_{th} (assuming that all changes in internal energy are associated only with *thermal* energy); Q is the amount of heat transferred *to* the system; and W is the amount of work done *on* the system. Note the italicized words "to" and "on." These words are short, yet important: They contain, in effect, the *sign convention*; that is, they help you choose a positive or negative sign for the quantities that enter your calculations. For instance, a positive value of heat indicates energy being transferred from the environment to the system. Similarly, when work is done on the system, energy is transferred to the system and $W > 0$.

We will usually assume that no changes in mechanical energy occur in thermodynamic processes; that is, $\Delta E_{\text{mech}} = 0$, so the previous equation can be rewritten as

$$\Delta E_{\text{sys}} = \Delta E_{\text{th}} = Q + W$$

The first law of thermodynamics can be written in more than one way. If, instead of the work done on the system, we consider the work done *by* the system on the environment, then energy is transferred from the system to the environment and the system's total energy decreases. Thus,

$$\Delta E_{\text{sys}} = \Delta E_{\text{th}} = Q - W$$

where W now represents the work done *by* the system. When using this form for the first law, remember that $W > 0$ when work is done by the system.

There is no particular advantage in using one form over the other. When you solve problems, be guided by your common sense. Ask yourself "Does energy increase or decrease as a result of this process?" And remember that *change* is always "the final quantity" minus "the initial quantity"--that is, the change in a certain physical quantity is *positive* when the quantity *increases* its value and *negative* when the quantity *decreases* its value.

Part A

A system dissipates 12 J of heat into the surroundings; meanwhile, 28 J of work is done on the system. What is the change of the internal energy ΔE_{th} of the system?

- ANSWER:
- -40 J
 - -16 J
 - 16 J
 - 40 J

Part B

A system absorbs 12 J of heat from the surroundings; meanwhile, 28 J of work is done on the system. What is the change of the internal energy ΔE_{th} of the system?

- ANSWER:
- -40 J
 - -16 J
 - 16 J
 - 40 J

Part C

A system absorbs 12 J of heat from the surroundings; meanwhile, 28 J of work is done by the system. What is the change of the internal energy ΔE_{th} of the system?

- ANSWER:
- -40 J
 - -16 J
 - 16 J
 - 40 J

Part D

A system experiences a change in internal energy of -36 kJ in a process that involves a transfer of 14 kJ of heat into the surroundings. Simultaneously, which of the following is true?

- ANSWER:
- 22 kJ of work is done by the system.
 - 22 kJ of work is done on the system.
 - 50 kJ of work is done by the system.
 - 50 kJ of work is done on the system.

Part E

A system experiences a change in internal energy of 36 kJ in a process that involves a transfer of 14 kJ of heat into the surroundings. Simultaneously, which of the

following is true?

- ANSWER:**
- 22 kJ of work is done by the system.
 - 22 kJ of work is done on the system.
 - 50 kJ of work is done by the system.
 - 50 kJ of work is done on the system.

Part F

A system experiences a change in internal energy of 14 kJ in a process that involves a transfer of 36 kJ of heat into the system. Simultaneously, which of the following is true?

- ANSWER:**
- 22 kJ of work is done by the system.
 - 22 kJ of work is done on the system.
 - 50 kJ of work is done by the system.
 - 50 kJ of work is done on the system.

Part G

In a certain process, the energy change of the system is 250 kJ. The process involves 480 kJ of work done by the system. Find the amount of heat Q transferred in this process.

Express your answer numerically in kilojoules. Make your answer positive if the heat is transferred into the system; make it negative if the heat is transferred into the surroundings.

ANSWER: $Q = 730 \text{ kJ}$

Part H

In a certain process, the energy change of the system is 250 kJ. The process involves 480 kJ of work done on the system. Find the amount of heat Q transferred in this process.

Express your answer numerically in kilojoules. Make your answer positive if the heat is transferred into the system; make it negative if the heat is transferred into the surroundings.

ANSWER: $Q = -230 \text{ kJ}$

Part I

In a certain process, the energy of the system decreases by 250 kJ. The process involves 480 kJ of work done on the system. Find the amount of heat Q transferred in this process.

Express your answer numerically in kilojoules. Make your answer positive if the heat is transferred into the system; make it negative if the heat is transferred into the surroundings.

ANSWER: $Q = -720 \text{ kJ}$