Physics 23 Chapter 15 Problems Dr. Alward

Recall:

-- $\Delta E = Q - W$
-- If work is done *by* a gas, W is positive. If work in done *on* a gas, W is negative.
-- Adiabatic Process: $Q = 0$
-- Isobaric Process: $W = P\Delta V$
-- Isothermal Process: $\Delta T = 0$
--Isochoric Process: $\Delta V = 0 \rightarrow W = 0$
-- $E = (3/2)nRT$ *only* for ideal *monatomic* gases.

1. 400 J of heat leaves 4.0 moles of an ideal monatomic gas, and while this is happening, 500 J of work is done on the gas. What is the temperature change of the gas?

2. 500 J of heat enters a gas, and while this is happening the internal energy decreases by 700 J. How much work was done, and was the work done *by* the gas, or *on* the gas? Did the gas expand, or was it compressed?

3. 600 J of heat enter a gas in an isobaric process at atmospheric pressure. The internal energy increases by 1000 J. What was the change in volume of the gas, and was it compressed, or expanded?

4. In a certain adiabatic process, the internal energy of a gas decreases by 600 J. How much work was done, and was the gas compressed, or expanded?

5. Two moles of an ideal monatomic gas undergo an isobaric (constant pressure) compression in which the change in volume is -4.0×10^{-3} m^3 as 500 joules of thermal energy leave the gas. The temperature of the gas rises by 4.5 K. What was the gas pressure?

6. 6000 J of work is done *on* argon gas at the same time that 4500 J of heat is removed. The gas temperature rises by 34.0 K. How many grams of argon are inside the container?

7. 300 J of heat enters a gas, and while this is happening the internal energy increases by 700 J. How much work was done by the gas? Was the gas expanded, or compressed?

Problem Solutions

1.

$\Delta E = (3/2)nR\Delta T$

$Q = -400$ J

$W = ?$

By Newton's 3rd Law, the work done *by* the gas is the negative of the work done *on* the gas:

Work Done on Gas: 500 J
Work Done *by* Gas: $W = -500$ J

$$\Delta E = Q - W$$
$$(3/2)(4.0)(8.31)\Delta T = -400 - (-500)$$
$$\Delta T = 2.01 \text{ C}$$

2.

$Q = 500$ J
$\Delta E = -700$ J

$$\Delta E = Q - W$$
$$-700 = 500 - W$$
$$W = 1200 \text{ J}$$

W is positive, so the work was done *by* the gas, which means the gas pushed against the walls of the container, causing them to move outward in the direction of the force. Thus, the gas *expanded*.

3.

$Q = 600$ J
$\Delta E = 1000$ J
$W = P\Delta V$
$= (101000)\Delta V$

$\Delta E = Q - W$

$1000 = 600 - 101000\,\Delta V$
$\Delta V = -0.00396 \text{ m}^3$

4.

Adiabatic:
$Q = 0$
$\Delta E = -600$
$W = ?$

$\Delta E = Q - W$
$-600 = 0 - W$
$W = 600$ J

The work done is positive, so the gas expanded. (See Problem 2.)

5. $(3/2)nR\Delta T = Q - W$
$= Q - P\Delta V$

$(3/2)\ (2.0)\ (8.31)(4.5) = -500 - P(-4.0 \times 10^{-3})$
$P = 153{,}046$ Pa

6. Argon is a monatomic ideal gas. Its atomic weight is 39.948.

$Q = -4500$ J

If work is done *on* a gas, the negative of that work is done *by* the gas:

$W = -6000$ J

$(3/2)\ n\ (8.31)\ (34.0) = -4500 - (-6000)$

$n = 3.539$
$m = 3.539\ (39.948)$
$= 141.38$ g

7. $Q = 300$ J
$\Delta E = 700$ J
$700 = 300 - W$
$W = -400$ J

The gas did negative work, which means the environment did positive work, which means the environment pushed on the walls of the container, compressing the gas.

Note: the "environment" could just be the atmosphere, or it could be a hand pushing downward on the moveable lid of a cylinder containing the gas.