Chapter 18 Problem 26 †

Given
$n_{O_2} = 2.5\ mol$
$n_{Ar} = 3.0\ mol$

Solution
Find the specific heats at constant volume and pressure for the mixture of these two gases.

Internal energy of the O_2 is

$$\Delta U_{O2} = n_{_{O2}} C_V \Delta T$$

O_2 is a diatomic gas and, therefore, the value of C_V is $5/2R$.

$$\Delta U_{O2} = (2.5\ mol)(\tfrac{5}{2}R)\Delta T = 6.25R\Delta T$$

Internal energy of the Ar is

$$\Delta U_{Ar} = n_{_{Ar}} C_V \Delta T$$

Ar is a monatomic gas and, therefore, the value of C_V is $3/2R$.

$$\Delta U_{Ar} = (3.0\ mol)(\tfrac{3}{2}R)\Delta T = 4.5R\Delta T$$

The internal energy of both gases combined is

$$\Delta U = \Delta U_{O2} + \Delta U_{Ar} = 6.25R\Delta T + 4.5R\Delta T$$

$$\Delta U = 10.75\ R\Delta T \tag{1}$$

Now for the mixed gas we also know that

$$\Delta U_{mixed} = n_{_{mixed}} C_V \Delta T \tag{2}$$

Comparing equations 1 and 2 we see that

$$n_{mixed} C_V = 10.75R$$

There is a total of 5.5 moles of gas and, therefore, the specific heat of the mixed gas is

$$C_V = \frac{10.75R}{n_{mixed}} = \frac{10.75R}{5.5} = 1.95R$$

The specific heat at constant pressure is

$$C_P = C_V + R = 1.95R + R = 2.95R$$

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†Problem from Essential University Physics, Wolfson