1 Problem 1

Find the mass in kilograms of 7.50×10^{24} atoms of arsenic, which has a molar mass of 74.9g/mol.

1.1 Solution

Convert atoms to moles.

$$\frac{7.50 \times 10^{24} \text{ atoms}}{6.02 \times 10^{23} \text{ atoms/mol}} = 12.458\text{mol} \tag{1}$$

Using the molar mass, convert moles to grams.

$$12.458\text{mol} * 74.9\text{g/mol} = 933.140\text{g} = \boxed{0.933\text{kg}} \tag{2}$$

2 Problem 3

Oxygen gas having a volume of 1000cm^3 at $40.0°\text{C}$ and $1.01 \times 10^5\text{Pa}$ expands until its volume is 1500cm^3 and its pressure is $1.06 \times 10^5\text{Pa}$. Find (a) the number of moles of oxygen present and (b) the final temperature of the sample.

2.1 Solution (a)

We can use the ideal gas law for this. We apply it to the first case, converting the $40.0°\text{C}$ to Kelvin.

$$40°\text{C} = 313.15\text{K} \tag{3}$$

$$1000\text{cm}^3 = 1000 \times 10^{-6}\text{m}^3 = 1 \times 10^{-3}\text{m}^3 \tag{4}$$

$$pV = nRT \tag{5}$$

$$n = \frac{pV}{RT} = \frac{1.01 \times 10^5\text{Pa} * 10^{-3}\text{cm}^3}{8.31\text{J/mol} \cdot \text{K} * 313.15\text{K}} \tag{6}$$

$$= \frac{1.01 \times 10^2\text{N} \cdot \text{m}}{2602.2765\text{J/mol}} = \boxed{0.038812\text{mol}} \tag{7}$$

2.2 Solution (b)

The ideal gas law (or an equivalent) will be used here. The number of moles does not change here, neither does the gas constant R. We can use ths to solve for the final value of the temperature.

$$\frac{p_1V_1}{n_1T_1} = \frac{p_2V_2}{n_2T_2} \tag{8}$$

$$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2} \tag{9}$$

$$T_2 = T_1 * \frac{p_2V_2}{p_1V_1} \tag{10}$$

We can substitute in values now.

$$T_2 = T_1 * \frac{p_2V_2}{p_1V_1} = 313.15 * \frac{1.06 \times 10^5 * 1500}{1.01 \times 10^5 * 1000} \tag{11}$$

$$= 313.15 * \frac{1.06 * 1.5}{1.01} = \boxed{492.97\text{K} \approx 220°\text{C}} \tag{12}$$

3 Problem 5

The best laboratory vacuum has a pressure of about 1.00×10^{-18}atm, or 1.01×10^{-13}Pa. How many gas molecules are there per cubic centimeter in such a vacuum at 293 K?

3.1 Solution

Use the ideal gas law, the version with Boltzmann's constant. We can solve for $\frac{N}{V}$.

$$pV = NkT \tag{13}$$

$$\frac{N}{V} = \frac{p}{kT} \tag{14}$$

From here, we can just plug and chug, so to speak.

$$\frac{N}{V} = \frac{1.01 \times 10^{-13}\mathrm{N/m^2}}{1.38 \times 10^{-23}\mathrm{N \cdot m/K} * 293\mathrm{K}} = \frac{1.01 \times 10^{10}}{404.34}\mathrm{m}^{-3} \tag{15}$$

$$= 24978978.09 \times \mathrm{m}^{-3} = \boxed{24.979\mathrm{cm}^{-3}} \tag{16}$$

4 Problem 7

Suppose 1.80 mol of an ideal gas is taken from a volume of 3.00 m^3 to a volume of 1.50 m^3 via an isothermal compression at 30°C. (a) How much energy is transferred as heat during the compression, and (b) is the transfer to or from the gas?

4.1 Solution (a)

Energy transfered can be thought of as work. We have a formula for work done by an ideal gas.

$$W = nRT \ln\left(\frac{V_f}{V_i}\right) \tag{17}$$

We can plug and chug into this.

$$T_K = T_C + 273.15\mathrm{K} = 30^\circ\mathrm{C} + 273.15\mathrm{K} = 303.15\mathrm{K} \tag{18}$$

$$W = (1.80\mathrm{mol})(8.31\mathrm{J/mol})(303.15\mathrm{K}) \ln\left(\frac{1.5\mathrm{m}^3}{3.0\mathrm{m}^3}\right) \tag{19}$$

$$= 4534.5177\mathrm{J} * (-0.693147) = -3143.088\mathrm{J} \tag{20}$$

The energy transfered is the absolute value of this, which would be $\boxed{3143.088\mathrm{J}}$.

4.2 Solution (b)

This is a volume compression process. The total energy in the system would remain constant, so $Q = W$ by the first law of thermodynamics. This means $Q < 0$, so the energy is transfered $\boxed{from}$ the gas as heat.

5 Problem 9

An automobile tire has a volume of $1.64 \times 10^{-2}\mathrm{m}^3$ and contains air at a gauge pressure (pressure above atmospheric pressure) of 165 kPa when the temperature is $0.00°\mathrm{C}$. What is the gauge pressure of the air in the tires when its temperature rises to $27.0°\mathrm{C}$ and its volume increases to $1.67 \times 10^{-2}\mathrm{m}^3$? Assume atmospheric pressure is $1.01 \times 10^5\mathrm{Pa}$.

5.1 Solution

6 Problem 11

Air that initially occupies 0.140 m3 at a gauge pressure of 103.0 kPa is expanded isothermally to a pressure of 101.3 kPa and then cooled at constant pressure until it reaches its initial volume. Compute the work done by the air. (Gauge pres- sure is the difference between the actual pressure and atmospheric pressure.)

6.1 Solution

7 Problem 13

A sample of an ideal gas is taken through the cyclic process abca shown in Fig. 19-20. The scale of the vertical axis is set by pb = 7.5 kPa and p ac = 2.5 kPa. At point a, T = 200 K. (a) How many moles of gas are in the sample? What are (b) the tem- perature of the gas at point b, (c) the temperature of the gas at point c, and (d) the net energy added to the gas as heat during the cycle?

7.1 Solution

8 Problem 17

Container A in Fig. 19-22 holds an ideal gas at a pressure of $5.0 \times 105Pa$ and a temperature of 300 K. It is connected by a thin tube (and a closed valve) to container B, with four times the volume of A. Container B holds the same ideal gas at a pressure of $1.0 \times 105Pa$ and a temperature of 400 K. The valve is opened to allow the pressures to equalize, but the temperature of each container is maintained. What then is the pressure?

8.1 Solution

9 Problem 19

(a) Compute the rms speed of a nitrogen molecule at 20.0°C. The molar mass of nitrogen molecules (N_2) is given in Table 19-1. At what temperatures will the rms speed be (b) half that value and (c) twice that value?

9.1 Solution

10 Problem 23

10.1 Solution

11 Problem 25

Determine the average value of the translational kinetic energy of the gas's molecules of an ideal gas at temperatures (a) 0.00°C and (b) 100°C. What is the translational kinetic energy per mole of an ideal gas at (c) 0.00°C and (d) 100°C?

11.1 Solution

12 Problem 27

12.1 Solution

13 Problem 31

In a certain particle accelerator, protons travel around a circular path of diameter 23.0 m in an evacuated chamber, whose residual gas is at 295 K and 1.00×10^{-6} torr pressure. (a) Calculate the number of gas molecules per cubic centimeter at this pressure. (b) What is the mean free path of the gas molecules if the molecu- lar diameter is 2.00×10^{-8}cm?

13.1 Solution

14 Problem 35

Ten particles are moving with the following speeds: four at 200m/s, two at 500m/s, and four at 600m/s. Calculate their (a) average and (b) rms speeds. (c) Is $v_{rms} > v_{avg}$?

14.1 Solution

15 Problem 37

15.1 Solution

16 Problem 39

16.1 Solution

17 Problem 43

The temperature of 3.00 mol of an ideal diatomic gas is increased by 40.0 C° without the pressure of the gas changing. The molecules in the gas rotate but do not oscillate. (a) How much energy is transferred to the gas as heat? (b) What is the change in the internal energy of the gas? (c) How much work is done by the gas? (d) By how much does the rotational kinetic energy of the gas increase?

17.1 Solution

18 Problem 45

18.1 Solution

19 Problem 47

19.1 Solution

20 Problem 51

When 1.0 mol of oxygen (O_2) gas is heated at constant pressure starting at 0°C, how much energy must be added to the gas as heat to double its volume? The molecules rotate but do not oscillate.

20.1 Solution

21 Problem 55

21.1 Solution

22 Problem 57

22.1 Solution

23 Problem 59

23.1 Solution

24 Problem 63

24.1 Solution

25 Problem 69

25.1 Solution

26 Problem 75

26.1 Solution

27 Problem 77

27.1 Solution

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