Answers to Exercise 9.6
Calculations for Ideal Gases

1.

(a) **Step 1: Convert temperature into Kelvin**

$T = 25 + 273.15 = 298.15\ K = 298\ K$

This value only has 3 sig. fig. because 25 ℃ has no decimal places; however, we will still use 298.15 K in the calculation to minimize rounding error.

Step 2: Convert* volume into m^3

$V = 1.000\ L \times \frac{1\ m^3}{1000\ L} = 1.000 \times 10^{-3}\ m^3$

Step 3: Convert* pressure into Pa

$P = 101.3\ kPa \times \frac{1000\ Pa}{1\ kPa} = 1.013 \times 10^5\ Pa$

Step 4: Calculate moles of gas

$PV = nRT$

$n = \frac{PV}{RT} = \frac{(1.013\times10^5\ Pa)(1.000\times10^{-3} m^3)}{\left(8.314\ 462 \frac{Pa\cdot m^3}{mol\cdot K}\right)(298.15\ K)} = 0.04086\ mol$

Step 5: Check your work

Does your answer seem reasonable? Are sig. fig. correct?

*Or leave volume in L and pressure in kPa and know that $8.314\ 462 \frac{Pa\cdot m^3}{mol\cdot K} = 8.314\ 462 \frac{kPa\cdot L}{mol\cdot K}$

(b) To calculate the molar mass of the gas from the number of moles of gas, we also need to know the mass of the gas $\left(M = \frac{m}{n}\right)$.

e.g. $M = \frac{m}{n} = \frac{10.0\ g}{0.04086\ mol} = 245\ \frac{g}{mol}$

(c) Heating the gas increases its volume (as long as neither pressure nor #moles changes).

Step 1: Convert temperature into Kelvin

$T = 65 + 273.15 = 338.15\ K = 338\ K$

This value only has 3 sig. fig. because 65 ℃ has no decimal places; however, we will still use 338.15 K in the calculation to minimize rounding error.

Step 2: Calculate new volume of gas

$PV = nRT$

$V = \frac{nRT}{P} = \frac{(0.04086\ mol)\left(8.314\ 462 \frac{Pa\cdot m^3}{mol\cdot K}\right)(338.15\ K)}{(1.013\times10^5\ Pa)} = 0.00113\ m^3 \times \frac{1000\ L}{1\ m^3} = 1.13\ L$

Step 3: Check your work

Does your answer seem reasonable? Are sig. fig. correct?

This volume is greater than the volume at 25 ℃, so it seems like a reasonable answer.

This calculation can also be performed using Charles' Law $\left(\frac{V_1}{T_1} = \frac{V_2}{T_2}\right)$.

2.

(a) Flask A will have a higher pressure. Because the molar mass of Ne is smaller, 25 g Ne corresponds to more moles than 25 g Xe. Since Flask A contains more moles of gas (at the same temperature and volume), it has a higher pressure.

(b) **Step 1: Convert temperature into Kelvin**

$T = 25 + 273.15 = 298.15\ K = 298\ K$

This value only has 3 sig. fig. because 25 ℃ has no decimal places; however, we will still use 298.15 K in the calculation to minimize rounding error.

Step 2: Convert* volume into m³

$V = 250\ mL \times \frac{1\ L}{1000\ mL} = 0.250\ L \times \frac{1\ m^3}{1000\ L} = 2.50 \times 10^{-4}\ m^3$

Step 3: Calculate the number of moles of each gas

$n_{Ne} = 2.5\ g \times \frac{1\ mol}{20.1797\ g} = 0.12\ mol$

$n_{Xe} = 2.5\ g \times \frac{1\ mol}{131.29\ g} = 0.019\ mol$

Step 4: Calculate pressure for each gas

$PV = nRT$

$P_{Ne} = \frac{nRT}{V} = \frac{(0.12\ mol)\left(8.314\ 462 \frac{Pa \cdot m^3}{mol \cdot K}\right)(298.15\ K)}{(2.50 \times 10^{-4} m^3)} = 1.2 \times 10^6\ Pa \times \frac{1\ bar}{10^5\ Pa} = 12\ bar$

$P_{Xe} = \frac{nRT}{V} = \frac{(0.019\ mol)\left(8.314\ 462 \frac{Pa \cdot m^3}{mol \cdot K}\right)(298.15\ K)}{(2.50 \times 10^{-4} m^3)} = 1.9 \times 10^5\ Pa \times \frac{1\ bar}{10^5\ Pa} = 1.9\ bar$

Step 5: Check your work

Does your answer seem reasonable? Are sig. fig. correct?

The pressure of the Ne was higher than the pressure of the Xe, as expected.

*Or convert volume into L and use $R = 8.314\ 462 \frac{kPa \cdot L}{mol \cdot K}$

Since units for the answer were not specified, it would be fine to leave the answers in Pa (or kPa).

3. **Step 1: Convert* volume into m³**

$V = 30\ L \times \frac{1\ m^3}{1000\ L} = 3.0 \times 10^{-2}\ m^3$

Step 2: Convert* pressure into Pa

$P = 1400\ kPa \times \frac{1000\ Pa}{1\ kPa} = 1.4 \times 10^6\ Pa$

Step 3: Calculate temperature

$PV = nRT$

$T = \frac{PV}{nR} = \frac{(1.4\times10^6\ Pa)(3.0\times10^{-2} m^3)}{(2.5\ mol)\left(8.314\ 462\frac{Pa\cdot m^3}{mol\cdot K}\right)} = 2021\ K$

Step 4: Convert temperature into degrees Celsius

$T = 2021 - 273.15 = 1747\ ℃ = 1.7 \times 10^3\ ℃$

Step 5: Check your work

Does your answer seem reasonable? Are sig. fig. correct?

This is a very high temperature, but the target pressure is also very high.

This answer suggests that overheating is not likely to cause properly inflated tires to burst if they are in good condition.

*Or leave volume in L and pressure in kPa and know that $8.314\ 462\frac{Pa\cdot m^3}{mol\cdot K} = 8.314\ 462\frac{kPa\cdot L}{mol\cdot K}$