P. 104 Ideal Gas Law

1) a) According to PV=nRT, it doesn't matter what gas is being observed. Under same conditions of Pressure, Volume, and Temperature, the number of moles (and thus number of molecules) is the same.

b) Even though all containers contain the same amount of molecules, the mass of those molecules (gas) will vary. Use n = m/M to solve for masses.

n=PV/RT
n= (104)(2) / (8.31)(295)
n= 0.085 moles of any gas

Helium(He):
n = m / M
0.085 = m / 4
0.34g

Oxygen(O_2):
n = m / M
0.085 = m / 32
2.72g

CarbonDioxide(CO_2):
n = m / M
0.085 = m / 44
3.74g

2.

1. Conversion of the temperature into kelvin:
$T = 20°C + 273 = 293\ K$

2. Calculation of the pressure:

$$PV = \frac{mRT}{M}$$

$$P = \frac{mRT}{MV}$$

$$= \frac{32.0\ \cancel{g} \cdot 8.31\ (kPa \cdot \cancel{L})/(\cancel{mol} \cdot \cancel{K}) \cdot 293\ \cancel{K}}{16.043\ \cancel{g/mol} \cdot 5.00\ \cancel{L}}$$

$$= 971\ kPa$$

Answer: The pressure exerted by the methane (CH_4) will be 971 kPa.

3.

1. Conversion of the temperature into kelvin:
$T = 35°C + 273 = 308\ K$

2. Conversion of mL into L:

$$\frac{1\ L}{1000\ mL} = \frac{x}{500\ mL}$$

$$x = \frac{1\ L \cdot 500\ \cancel{mL}}{1000\ \cancel{mL}} = 0.500\ L$$

3. Calculation of the number of moles:

$$PV = nRT$$

$$n = \frac{PV}{RT}$$

$$= \frac{210\ kPa \cdot 0.500\ L}{8.31\ (\cancel{kPa} \cdot \cancel{L})/(\cancel{mol} \cdot \cancel{K}) \cdot 308\ K}$$

$$= 4.10 \times 10^{-2}\ \cancel{mol}$$

Answer: The sample contains 4.10×10^{-2} mol of methane (CH_4).

4.

1. Calculation of the temperature:

$$PV = \frac{mRT}{M}$$

$$T = \frac{PVM}{mR}$$

$$= \frac{85\ \cancel{kPa} \cdot 30\ L \cdot 17.031\ \cancel{g/mol}}{10.5\ \cancel{g} \cdot 8.31\ (\cancel{kPa} \cdot L)/(\cancel{mol} \cdot K)}$$

$$= 497.73\ K$$

2. Conversion of the temperature into degrees Celcius:
$T_2 = 497.73\ K - 273 = 224.73°C$

Answer: At a temperature of 225°C.

5.

1. Conversion of the temperature into kelvin:
$T = 35°C + 273 = 308\ K$

2. Conversion of mL into L:

$$\frac{1\ L}{1000\ mL} = \frac{x}{500\ mL}$$

$$x = \frac{1\ L \cdot 500\ \cancel{mL}}{1000\ \cancel{mL}} = 0.500\ L$$

3. Calculation of the number of moles:

$$PV = nRT$$

$$n = \frac{PV}{RT}$$

$$= \frac{210\ \cancel{kPa} \cdot 0.500\ \cancel{L}}{8.31\ (\cancel{kPa} \cdot \cancel{L})/(mol \cdot \cancel{K}) \cdot 308\ \cancel{K}}$$

$$= 4.10 \times 10^{-2}\ mol\ or\ 41\ mol$$

Answer: The sample contains 4.10×10^{-2} mol of methane (CH_4).

6.

1. Conversion of the temperature into kelvin:
$T = 40°C + 273 = 313\ K$

2. Calculation of the pressure:

$$PV = nRT$$

$$P = \frac{nRT}{V}$$

$$= \frac{30\ \cancel{mol} \cdot 8.31\ (kPa \cdot \cancel{L})/(\cancel{mol} \cdot \cancel{K}) \cdot 313\ \cancel{K}}{50\ \cancel{L}}$$

$$= 1560.618\ kPa$$

Answer: The pressure exerted in the compressed air cylinder is 1.6×10^3 kPa or 1.6 MPa.

7. *1. Conversion of kg into g:*

$$\frac{1\text{ kg}}{1000\text{ g}} = \frac{50\text{ kg}}{x}$$

$$x = \frac{1000\text{ g} \cdot 50\text{ }\cancel{\text{kg}}}{1\text{ }\cancel{\text{kg}}} = 50\ 000\text{ g}$$

2. Conversion of the temperature into kelvin:

$T = 125°C + 273 = 398\text{ K}$

3. Calculation of the volume:

$$PV = \frac{mRT}{M}$$

$$V = \frac{mRT}{MP}$$

$$= \frac{50\ 000\text{ }\cancel{\text{g}} \cdot 8.31\ (\cancel{\text{kPa}} \cdot \cancel{\text{L}})/(\cancel{\text{mol}} \cdot \cancel{\text{K}}) \cdot 398\text{ }\cancel{\text{K}}}{31.998\text{ }\cancel{\text{g/mol}} \cdot 150\text{ }\cancel{\text{kPa}}}$$

$$= 34\ 454\text{ L}$$

Answer: The volume occupied by the oxygen (O_2) gas is 3.4×10^4 L or 34 kL.

8. *1. Calculation of the temperature:*

$$PV = \frac{mRT}{M}$$

$$T = \frac{PVM}{mR}$$

$$= \frac{85\text{ }\cancel{\text{kPa}} \cdot 30\text{ }\cancel{\text{L}} \cdot 17.031\text{ }\cancel{\text{g/mol}}}{10.5\text{ }\cancel{\text{g}} \cdot 8.31\ (\cancel{\text{kPa}} \cdot \cancel{\text{L}})/(\cancel{\text{mol}} \cdot \text{K})} = 497.73\text{ K}$$

2. Conversion of the temperature into degrees Celsius:

$T = 497.73\text{ K} - 273 = 224.73°C$

Answer: 10.5 g of ammonia (NH_3) gas exerts a pressure of 85 kPa in a 30-L container at 225°C.

9. *1. Conversion of the temperature into kelvin:*

$T = 100°C + 273 = 373\text{ K}$

2. Calculation of the molar mass:

$$PV = \frac{mRT}{M}$$

$$M = \frac{mRT}{PV}$$

$$= \frac{5.4\text{ g} \cdot 8.31\ (\cancel{\text{kPa}} \cdot \cancel{\text{L}})/(\text{mol} \cdot \cancel{\text{K}}) \cdot 373\text{ }\cancel{\text{K}}}{26.6\text{ }\cancel{\text{kPa}} \cdot 2.6\text{ }\cancel{\text{L}}}$$

$$= 242\text{ g/mol}$$

Answer: The molar mass of the gas is 2.4×10^2 g/mol.

10. *1. Conversion of the temperature into kelvin:*

$T = 40°C + 273 = 313\text{ K}$

2. Calculation of the molar mass:

$$PV = \frac{mRT}{M}$$

$$m = \frac{PVM}{RT}$$

$$= \frac{200\text{ }\cancel{\text{kPa}} \cdot 20\text{ }\cancel{\text{L}} \cdot 64.063\text{ g/}\cancel{\text{mol}}}{8.31\ (\cancel{\text{kPa}} \cdot \cancel{\text{L}})/(\cancel{\text{mol}} \cdot \cancel{\text{K}}) \cdot 313\text{ }\cancel{\text{K}}} = 99\text{ g}$$

Answer: The mass of sulphur dioxide (SO_2) in the cylinder is 99 g.

11. *1. Conversion of the temperature into kelvin:*

$T = 249°C + 273 = 522\text{ K}$

2. Calculation of the molar mass:

$$PV = \frac{mRT}{M}$$

$$M = \frac{mRT}{PV}$$

$$= \frac{62\text{ g} \cdot 8.31\ (\cancel{\text{kPa}} \cdot \cancel{\text{L}})/(\cancel{\text{mol}} \cdot \cancel{\text{K}}) \cdot 522\text{ }\cancel{\text{K}}}{200\text{ }\cancel{\text{kPa}} \cdot 10\text{ }\cancel{\text{L}}}$$

$$= 134.5\text{ g/mol}$$

Answer: The molar mass of the gas is 1.3×10^2 g/mol.

12. *a) 1. Conversion of the temperature into kelvin:*

$T = 23.4°C + 273 = 296.4\text{ K}$

2. Calculation of the mass of the gas in the cylinder:

$m = 9.31\text{ g} - 7.02\text{ g} = 2.29\text{ g}$

3. Calculation of the molar mass:

$$PV = \frac{mRT}{M}$$

$$M = \frac{mRT}{PV}$$

$$= \frac{2.29\text{ g} \cdot 8.31\ (\cancel{\text{kPa}} \cdot \cancel{\text{L}})/(\text{mol} \cdot \cancel{\text{K}}) \cdot 296.4\text{ }\cancel{\text{K}}}{102.2\text{ }\cancel{\text{kPa}} \cdot 1.25\text{ }\cancel{\text{L}}}$$

$$= 44.2\text{ g/mol}$$

Answer: The molar mass of the gas is 44.2 g/mol.

b) The gas could be carbon dioxide (CO_2).

13. *1. Conversion of the temperature into kelvin:*

$T = 0°C + 273 = 273\ K$

2. Calculation of the number of moles:

$PV = nRT$

$$n = \frac{PV}{RT}$$

$$= \frac{101.3\ \cancel{kPa} \cdot 11.2\ \cancel{L}}{8.31\ (\cancel{kPa} \cdot \cancel{L})/(mol \cdot \cancel{K}) \cdot 273\ \cancel{K}} = 0.500\ mol$$

Answer: The sample contains 0.500 mol.

14. *1. Conversion of the temperature into kelvin:*

$T = -45°C + 273 = 228\ K$

2. Calculation of the volume:

$PV = nRT$

$$V = \frac{nRT}{P}$$

$$= \frac{10\ \cancel{mol} \cdot 8.31\ (\cancel{kPa} \cdot L)/(\cancel{mol} \cdot \cancel{K}) \cdot 228\ \cancel{K}}{75.5\ \cancel{kPa}}$$

$$= 250.95\ L$$

Answer: The volume of the balloon is 2.5×10^2 L.

15. *1. Conversion of mL into L:*

$$\frac{1\ L}{1000\ mL} = \frac{x}{180\ mL}$$

$$x = \frac{1\ L \cdot 180\ \cancel{mL}}{1000\ \cancel{mL}} = 0.180\ L$$

2. Conversion of the temperature into kelvin:

$T = 20°C + 273 = 293\ K$

3. Calculation of the pressure:

$PV = nRT$

$$P = \frac{nRT}{V}$$

$$= \frac{5.8 \cdot 10^{-3}\ \cancel{mol} \cdot 8.31\ (kPa \cdot \cancel{L})/(\cancel{mol} \cdot \cancel{K}) \cdot 293\ \cancel{K}}{0.180\ \cancel{L}}$$

$$= 78.46\ kPa$$

Answer: The pressure of the argon (Ar) inside the bulb is 78 kPa.

16. *1. Calculation of the temperature:*

$PV = nRT$

$$T = \frac{PV}{nR}$$

$$= \frac{135\ \cancel{kPa} \cdot 13.65\ \cancel{L}}{0.75\ \cancel{mol} \cdot 8.31\ (\cancel{kPa} \cdot \cancel{L})/(\cancel{mol} \cdot K)} = 295.67\ K$$

2. Conversion of the temperature into degrees Celsius:

$T = 295.67\ K - 273 = 22.67°C$

Answer: The temperature of the chlorine (Cl_2) gas is 23°C.