1. (30 pts) 10 L of a gas mixture contains 5 g of O_2, 3 g of N_2 and 1 g of He. Calculate the partial pressure of O_2 and the total pressure if the temperature is 100 °C.

   Atomic mass: O=16
   N=14
   He=4

$P_{O2}=$	$P_{total}=$
48.47 Pa	159.15 Pa

2. (40 pts) A piston-cylinder device contains 10 moles of air at T=800 K and P=4 bar. This air undergoes an adiabatic and reversible expansion from 800 K and 4 bar. If you need to produce 100kJ of work, determine the final temperature and volume of the air (assume ideal gas). For this range of temperature, $C_{p, air}=7/2R$

   T= 318.88 K
   V= 1.66 m³

3. (30 pts) Calculate the standard enthalpy of formation of acetylene gas ($C_2H_{2(g)}$) from $C_{(s)}$ and $H_{2(g)}$ at 25 °C using the following standard heats of combustion at 25 °C. Is the formation reaction for acetylene endothermic or exothermic?

Combustion reactions	$\Delta H°$ of combustion, kJ/mol
$C_2H_{2(g)} + (5/2)O_{2(g)} = 2CO_{2(g)}+H_2O_{(l)}$	-1299.58
$C_{(s)} + O_{2(g)} = CO_{2(g)}$	-393.51
$H_{2(g)} + (1/2)O_{2(g)} = H_2O_{(l)}$	-285.83

   $\Delta H°_{f,C_2H_2} =$ 226.73 kJ/mol (endothermic)

   Values of the Universal Gas constant:
   R = 0.0831 bar*L/(mol*K)
   R = 8.31 J/(mol*K)

Idea gas equation of state: $PV = nRT$

Compressibility factor: $Z = \dfrac{PV}{nRT}$

Virial equation of state:

$$Z = \frac{PV}{nRT} = 1 + \frac{nB}{V} + \frac{n^2C}{V^2} + \dots$$

Van der Waals equation of state:

$$P = \frac{nRT}{(V - nb)} - \frac{an^2}{V^2}$$

$$a = \frac{27R^2T_c^2}{64P_c}$$

$$b = \frac{RT_c}{8P_c} = \frac{V_c}{3}$$

$H \equiv U + PV$

$dH = nC_p dT$

For ideal gases, $C_p = C_v + R$

Adiabatic reversible compression or expansion of an ideal gas:

$$\frac{T_2}{T_1} = \left(\frac{V_2}{V_1}\right)^{-R/C_v}$$

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{R/C_p}$$

$$P_1 V_1^\gamma = P_2 V_2^\gamma \qquad \gamma = \frac{C_p}{C_v}$$

$dW = -P_{ext}.dV$

First law, closed systems
$$\Delta U = Q + W \qquad \text{or} \qquad dU = dQ + dW$$

$dU = nC_v dT$

For an isothermal process (ideal gas):

$$W_{rev} = -\int_{V_1}^{V_2} \frac{nRT}{V} dV = -nRT \ln\frac{V_2}{V_1} = -nRT \ln\frac{P_1}{P_2}$$

Extent of reaction (ξ) => $\Delta n_i = \upsilon_i * \xi$

υ_i: stoichiometric coefficient
$\Delta H_{rxn} = \Sigma \, \upsilon_i * [\Delta H^\circ_{f,i} + C_{p,i} * (T-25^\circ C)]$
Assuming no phase change, constant C_p

First law for closed systems, with reaction:
$\Delta H + \xi * \Delta H_{rxn} = Q + W_{shaft} + V * \Delta P$
W_{shaft} does not include expansion $(-P\Delta V)$