Introduction to thermodynamics Part 1 : Answers.

1) the external pressure is constant, so can use $W = -P\Delta V$

To start, convert the pressure and volumes to SI units.

$1\ atm = 101325\ Nm^{-2}$ and $1\ dm^3 = 1\times10^{-3}\ m^3$

$W = -P_{ext}\Delta V = -(101325\ Nm^{-2}) \times [(10-5)\times10^{-3}]\ m^3$

$= -506.6\ Nm = -506.6\ J.$

2. $1\ bar = 100,000\ Nm^{-2}$ $\quad 1dm^3 = 1\times10^{-3}\ m^3$

$W = -(100000 \times 1\times10^{-3}) = -100\ J$

3. $R = 8.314\ Jmol^{-1}K^{-1}$ $\quad T = 298K$ $\quad 20\ bar = 2\times10^6\ Nm^{-2}$

Use $PV = nRT$ to find volume by rearranging

$V = \frac{nRT}{P}$, then find moles of oxygen in 10kg

moles $= 10000/32 = 312.5\ mol$

$V = \frac{nRT}{P} = \frac{312.5\times8.314\times298}{2\times10^6} = 0.39\ m^3$

4. $1\ atm = 101325\ Nm^{-2}$ $\quad T = 298K$

$1 = 1\ bar = 1\times10^5\ Pa$

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ so $\frac{1\times10^5\ V_1}{298} = \frac{P_2V_2}{T_2}$

Firstly calculate V_1 : $PV = nRT$ $\quad V = \frac{nRT}{P} = \frac{1\times8.314\times298}{1\times10^5} = 0.02\ m^3$

$\frac{1\times10^5\times0.02}{298} = \frac{P_2V_2}{298K}$: volume is halved

$\frac{1\times10^5\times0.02}{298} = \frac{P_2\times0.01}{298}$: $P_2 = \frac{1\times10^5\times0.02}{0.01} = 2\times10^5\ Pa.$

5. $PV = nRT$

We know n, T, R and P

$1\ atm = 101\,325\ Nm^{-2}$

$$V = \frac{nRT}{P} = \frac{1 \times 8.314 \times 298}{101325} = 0.0245\ m^3$$

6. $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

10g of CH_4

Begin by working out moles of $CH_4 = 10 / 14.02 = 0.71$ moles.

There is a 1:2 molar ratio of $CH_4 : O_2$

So 0.713 moles $CH_4 = 1.426$ moles O_2.

$PV = nRT$ $\quad V = \frac{nRT}{P} = \frac{1.426 \times 8.314 \times 298}{101325}$

$= 0.034\ m^3$.