Problems of Chapter 15

(2) $Q = 550 \text{ J}$ $\quad W = -840 \text{ J}$ (work is done by the system)

$$\Delta U = Q + W = 550 - 840$$

$$\boxed{\Delta U = -290 \text{ J}}$$

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(4) $Q = 135 \text{ J}$

$$V_2 = V_1 + at$$

$$3 = 0 + 3a \rightarrow \boxed{a = 1 \, m/s^2}$$

$$F = ma = \underbrace{(m + m + \dots + m)}_{9 \text{ of them}} a$$

$$F = (9 \text{ kg})(1) = 9 \text{ N}.$$

$$\text{Work} = W = F d$$

$$= (9 \text{ N})(4.5) = \boxed{40.5 \text{ J}}$$

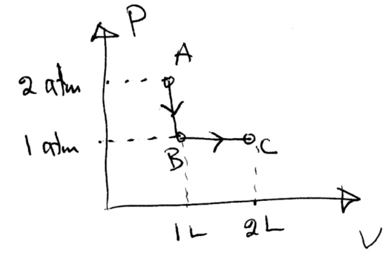
W is going to be negative because it is the work done by the system.

$$\Delta U = Q + W$$

$$= 135 - 40.5$$

$$\boxed{\Delta U = 94.5 \text{ J}}$$

(6)



$A \to B$: $W = 0$

because $\Delta V = 0$

$B \to C$ $W = P \Delta V$

$= (1.0 \text{ atm} \times 1.013 \times 10^{5} \text{ Pa/atm})(2-1) \times 10^{-3}$ m^3

$$\boxed{W = 101.3 \text{ J}}$$

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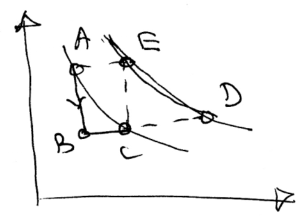
(8)



a) $W_{AB} = 0$; $(\Delta V = 0)$

$W_{BCD} = P \Delta V$

$= (1 \times 1.013 \times 10^{5})(\cancel{16-4}^{12}) \times 10^{-3}$

$W_{BCD} = 1216.0$ J $\Rightarrow$ $\boxed{W_{ABCD} = 1216.0 \text{ J}}$

Important: Sign of W_{ABCD} is "negative", that is $W_{ABCD} = -1216$ J. Since the gas is expanding, its internal energy must decrease and thus $W < 0$.

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8- Continues

TOTAL heat flow = ?

notice the negative sign

$$\Delta U_{AB} = Q_{AB} + \cancel{W_{AB}}_{0} \Rightarrow \boxed{Q_{AB} = -607.8\,J}$$

$$\Delta U_{BD} = Q_{BD} + W_{BD}$$

$$\downarrow$$

$$1823.4 = Q_{BD} + (-1216) \Rightarrow \boxed{Q_{BD} = 3039.4\,J}$$

$$Q_{tot} = 3039.4 - 607.8$$

$$\boxed{Q_{tot} = 2431.6\,J}$$

(12) $n = 1$ mole of oxygen $= O_2$

$P_1 = 1$ atm $=$ Constant

$T_1 = 10^\circ C$ $\quad T_2 = 25^\circ C$

a) $Q = n C_p \Delta T = (1)(\frac{7}{2} \times 8.31)(25-10)$

$\boxed{Q = 436\ J}$

b) $\left.\begin{array}{l} P_1 V_1 = nRT_1 \\ P_2 V_2 = nRT_2 \end{array}\right\} \rightarrow \begin{array}{l} V_1 = \frac{nRT_1}{P} \\ V_2 = \frac{nRT_2}{P} \end{array} \Rightarrow$

$$\Delta V = V_2 - V_1 = \frac{nR}{P}(T_2 - T_1)$$

$$= \frac{(1)(8.31)}{1.013 \times 10^5}(25-10) = 1.23 \times 10^{-3}\ m^3$$

$\boxed{\Delta V = 1.23\ L}$

c) $W = P\Delta V = (1.013 \times 10^5)(1.23 \times 10^{-3}) = \boxed{125\ J}$

d) $\Delta U = Q + W$

$\Delta U = 436 - 125 = \boxed{312\ J}$

gas expands; $\underline{W < 0}$

(16) $e = 0.21$ $Q_H = 1000\ J$

a) $W_{net} = ?$

$$e = \frac{W_{net}}{Q_H} \Rightarrow 0.21 = \frac{W_{net}}{1000}$$

$$\boxed{W_{net} = 210\ J}$$

b) $Q_c = ?$ $W_{net} = Q_H - Q_c \Rightarrow 1000 - Q_c = 210$

$$\boxed{Q_C = 790\ J}$$

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(14) $Q_H = 7.81 \times 10^3\ J/s$ in 10 hours

$K_P = 6.85$

$Q_C = ?$

$$K_P = \frac{Q_H}{W_{net}} = \frac{Q_H}{Q_H - Q_c} \Rightarrow 6.85 = \frac{7810}{7810 - Q_C}$$

$$\Rightarrow 6.85 \times 7810 - 6.85\, Q_C = 7810$$

$$Q_C = 6.67 \times 10^3\ J \quad \text{per second.}$$

In 10 hours
$$Q_C = (6.67 \times 10^3)(10 \times 3600)$$
$$= \boxed{240 \times 10^6\ J}$$

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(24) $e = 0.725 \quad T_H = 622\,k \quad T_c = ?$

$$e = 1 - \frac{T_c}{T_H} \Rightarrow 0.725 = 1 - \frac{T_c}{622} \Rightarrow \boxed{T_c = 171\,k}$$

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(28) $T_H = 650\,k \quad T_c = 350\,k \quad e = 0.65\, e_{max}$

a) $e = ?$ $\quad e_{max} = e_{Carnot} = 1 - \frac{T_C}{T_H} = 1 - \frac{35\cancel{0}}{65\cancel{0}}$

$$e_{Carnot} = 0.46$$

$$e_{engine} = (0.65)(0.46) = \boxed{0.3} = 30\%$$

b) $Q_C = 6.3 \times 10^3\,J$

$W = ?$

$$e = 1 - \frac{Q_C}{Q_H} \rightarrow 0.3 = 1 - \frac{6.3 \times 10^3}{Q_H}$$

$$Q_H = 9000\,J$$

$$W = Q_H - Q_C = 9000 - 6300 = \boxed{2700\,J}$$

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(32) $T_H = 20^\circ C = 293\,k \quad T_C = -10^\circ C = 263\,k$

$Q_H = 1000\,J \quad W_{min} = ?$

W_{min} Corresponds to a Carnot engine (or heat Pump).

$$K_p = \frac{Q_H}{W} = \frac{1}{1 - T_C/T_H} \Rightarrow \frac{1000}{W} = \frac{1}{1 - \frac{263}{293}} \Rightarrow$$

for a Carnot engine

$$\boxed{W = 1000\,J}$$