Q-7

① $W = \Delta H$

$$\Delta H = H(2\,bar, 54.5°C) - H(100\,bar, 225°C)$$

$$H(2\,bar, 54.5°C) = H_{ref} + \int_{T_{ref}}^{54.5} C_p\,dT + H^R(2\,bar, 54.5°C)$$

$$H(100\,bar, 225°C) = H_{ref} + \int_{T_{ref}}^{225} C_p\,dT + H^R(100\,bar, 225°C)$$

$$\Delta H = \int_{225°C}^{54.5°C} C_p\,dT + \left[H^R(2\,bar, 54.5°C) - H^R(100\,bar, 225°C)\right]$$

$$\Delta H = \Delta H^{ig} + \Delta H^R$$

$$\Delta H^{ig} = \int_{225+273}^{54.5+273} (0.1562T + 27.9)\,dT$$

$$\Delta H^{ig} = \frac{0.1562\,T^2}{2} + 27.9T \Big|_{225+273}^{54.5+273}$$

$$\Delta H^{ig} = \left[\frac{0.1562}{2}(54.5+273)^2 + 27.9(54.5+273)\right] - \left[\frac{0.1562}{2}(225+273)^2 + 27.9(225+273)\right]$$

$$\Delta H^{ig} = 17\,513.96 - 33\,263.3 = -15\,749.3\ J/mol$$

$$\Delta H^R = H^R(2\text{bar}, 54.5°C) - H^R(100\text{bar}, 225°C)$$

$H^R(2\text{bar}, 54.5°C)$

$T_R = 0.89 \quad P_R = 0.047$

$$\frac{H^R}{RT_C} = P_R\left[B^\circ - T_R\frac{dB^\circ}{dT_R} + \omega\left(B' - T_R\frac{dB'}{dT_R}\right)\right]$$

$$B^\circ = 0.083 - \frac{0.422}{T_R^{1.6}} = -0.43$$

$$B' = 0.139 - \frac{0.172}{T_R^{4.2}} = -0.14$$

$$\frac{dB^\circ}{dT_R} = \frac{0.675}{T_R^{2.6}} = 0.91$$

$$\frac{dB'}{dT_R} = \frac{0.722}{T_R^{5.2}} = 1.32$$

$$\frac{H^R}{RT_C} = 0.047\left[-0.43 - 0.89 \times 0.91 + 0.152\left(-0.14 - 0.89 \times 1.32\right)\right]$$

$$\frac{H^R}{RT_C} = -0.068$$

$$H^R(2\text{bar}, 54.5°C) = -208\ \text{J/mol}$$

H^R (100 bar, 225°C)

$T_R = 1.35$ $P_R = 2.35$

$B^0 = -0.178$ $B^1 = 0.09$

$\frac{dB^0}{dT_R} = 0.309$ $\frac{dB^1}{dT_R} = 0.152$

$$\frac{H^R}{RT_c} = 2.35\left[-0.178 - 1.35 \times 0.309 + 0.152 \times \left(0.09 - 1.35 \times 0.152\right)\right]$$

$$\frac{H^R}{RT_c} = -1.44$$

$H^R = -4426.5$ J/mol

$\Delta H = -15749.3 + (-208 + 4426.5) = -11530.8$ J/mol

or (considering final state to be ideal gas) (Either is OK)

$\Delta H = -15749.3 + (0 + 4426.5) = -11322.8$ J/mol

∴ Work from turbine is -11.5 kJ/mol

② From Figure 3.14, the analytical form is not accurate because Pr is too high and Tr is too low. It would be best to use tabulated form.