20 g = 20/18 mol; \( \Delta H_{\text{fus}} = 6677.8 \text{ J} \); \( C_p = 75(20/18) = 83.33 \text{ J K}^{-1} \) (for 20 g)

40 g = 40/18 mol; \( C_p = 166.67 \text{ J K}^{-1} \) (for 40 g)

a. Since all the ice melts, let the final temperature be \( t \):

\[
6677.8 + 83.33(t - 0) = 166.67(80 - t)
\]

(heat ice) (heat melted ice) (cool original liq. water)

\( t = 26.6 \degree C = 299.8 \text{ K} \)

b. 1. reversibly melt ice at \( 0 \degree C \): \( \Delta S_1 = 6677.8/273 = 24.460 \)

11. rev. heat 20 g liq to 299.8: \( \Delta S_{11} = 83.33 \ln(299.8/273) = 7.803 \)

11. rev. cool 40 g liq. to 299.8: \( \Delta S_{\text{III}} = 166.67 \ln(299.8/353) = -27.226 \)

IV. add the two batches of water: \( \Delta S_{\text{IV}} = 0 \)

\[
\Delta S_{\text{syst}} = \Delta S_1 + \Delta S_{11} + \Delta S_{\text{III}} + \Delta S_{\text{IV}} = +5.037 \text{ J K}^{-1}
\]

\[
\Delta S_{\text{surr}} = -\Delta S_{\text{syst}} = -5.037 \text{ J K}^{-1} ; \quad \Delta S_{\text{tot}} = \Delta S_{\text{syst}} + \Delta S_{\text{surr}} = 0.
\]

c. \( \Delta S_{\text{syst}} \) must be the same as in part (b) or \(+5.037 \text{ J K}^{-1} \). In the irreversible addition there is no interaction with the surroundings, thus \( \Delta S_{\text{tot}} = 0 \), and \( \Delta S_{\text{surr}} = 0 \), and \( \Delta S_{\text{tot}} = \Delta S_{\text{syst}} + \Delta S_{\text{surr}} = +5.037 \text{ J K}^{-1} \).

13. I.G. \((T_1, V_1, 1 \text{ mol}) + I.G. \((T_2, V_2, 1 \text{ mol}) \) \( (V_2 > V_1 \text{ for expansion}) \)

Carry out the process in two stages to get the same change

1. Isothermal expansion \( V_1 \rightarrow V_2 \) at \( T_1 \): \( \Delta S_1 = R \ln(V_2/V_1) \)

II. Heat from \( T_1 \rightarrow T_2 \) at constant \( V \): \( \Delta S_{11} = C_V \ln(T_2/T_1) \)

\[
\Delta S_{\text{process}} = \Delta S_1 + \Delta S_{11} = R \ln(V_2/V_1) + C_V \ln(T_2/T_1)
\]

Using Eq. (5.29) the terms add to give \( \Delta S_{\text{tot}} = 0 \) for the rev. process.

For an irreversible process, \( \Delta S_1 \) is the same as for the reversible process, and note that \( \Delta S_1 > 0 \) for an expansion. Since \( \Delta T_{\text{rev}} < \Delta T_{\text{irrev}} \), \( \Delta S_{11} \) must be smaller for the irreversible than for the reversible process, and hence \( \Delta S_{\text{tot}} > 0 \).

16. \( V = nRT/P \); \((\partial V/\partial T)_P = nR/P \); Using Eq. (8.29) or previous problem

\[
(\partial H/\partial P)_T = V - T(\partial V/\partial T)_P = nRT/P - nRT/P = 0
\]

17. \((\partial E/\partial V)_T = (\partial P/\partial T)_V - P \) By Eq. (8.25) (valid for any substance.)

for vdw gas, \( (P + a/V^2)/(V - b) = RT \) which can be rearranged to

\[
P = RT/(V - b) - a/V^2; \quad (\partial P/\partial T)_V = R/(V - b); \quad \text{use this in first equation}
\]

\[
(\partial E/\partial V)_T = RT/(V - b) - RT/(V - b) + a/V^2 = a/V^2 \text{ (vdw gas)}
\]