27) a + c spontaneous   28) a + c non spontaneous; Not impossible - add work

35) a) $\Delta S(+)$ gas produced  b) $\Delta S(-)$ 2 mol gas → 1 mol  c) $\Delta S(-)$ s to g  d) $\Delta S(-)$ 4 → 2 gas

37) a) $\Delta S_{sys}(+)$ 6 → 7 gas because $\Delta H$ is $(-)$ $\Delta S_{surr}(+)$ reaction is spontaneous at all temperatures

b) $\Delta S_{sys}(-)$ 2 moles of diff gases to 2 mol of 1 gas $\Delta H(+)$ and $\Delta S_{surr}(-)$ nonspont at all T

c) $\Delta S_{sys}(-)$ 3 → 2 $\Delta H(+)$ and $\Delta S_{surr}(-)$ non spon @ all T

d) $\Delta S_{sys}(+)$ 9 → 10 $\Delta H(-)$ and $\Delta S_{surr}(+)$ spont @ all T

39) a) $\Delta S_{surr} = \dfrac{-\Delta H_{sys}}{T} = \dfrac{-(-385,000\,J)}{298\,K} = 1290\,J/K$

b) $\Delta S_{surr} = \dfrac{-(-385,000\,J)}{77\,K} = 5.00 \times 10^{3}\,J/K$  d) $\Delta S_{surr} = \dfrac{-(114,000\,J)}{77\,K} = -1480\,J/K$

c) $\Delta S_{surr} = \dfrac{-(114,000\,J)}{298\,K} = -383\,J/K$

41) a) $\Delta S_{surr} = \dfrac{(115,000\,J)}{298\,K} = -385.9\,J/K$   $\Delta S_{univ} = \Delta S_{sys} + \Delta S_{surr}$
$= -263\,J/K - 385.9\,J/K = -649\,J/K$ Non

43) a) $\Delta G = \Delta H - T\Delta S = 115\,KJ - ((298\,K)(-0.263\,KJ/K)) = 193\,KJ$ Non spont

41) b) $\Delta S_{surr} = \dfrac{-(-115,000\,J)}{298\,K} = 385.9\,J/K$  $\Delta S_{univ} = +263\,J/K + 385.9\,J/K = 649\,J/K$

43) b) $\Delta G = -115\,KJ - ((298\,K)(0.263\,KJ/K)) = -193\,KJ$ Spont

45) $\Delta G = \Delta H - T\Delta S = -2217\,KJ - ((298\,K)(0.1011\,KJ/K)) = -2247\,KJ$ Spont

49) Molar entropy ↑ with ↑ T  KE + molecular motion ↑ Substance has access to ↑ # of energy levels

50) 3rd Law states entropy of perfect crystal @ 0K = 0  for enthalpy we defined a standard state to define zero for the scale. Not necessary for entropy Since there is an abs. zero for the entropy scale

51) a) $CO_2 > CO$ → higher molar mass/complexity   d) $SiH_4 > CH_4$ greater mass/complex

b) $CH_3OH_{(g)} > (\ell)$  gas   e) $CH_3CH_2CH_3 > NO_2$  " "

c) $CO_{2(s)} > Ar_{(s)}$ higher mass/complex   f) $NaBr_{(aq)} > (s)$ more entropy

53) a) $He < Ne < SO_2 < NH_3 < CH_3CH_2OH$  all gas  ↑MM and complexity

b) $H_2O (s) < (l) < (g)$  c) $CH_4 < CF_4 < CCl_4$  ↑MM

55) a) $\Delta S° = P - R$  $[229.2 J/K] - [(219.3) + (130.7)] = -120.8 J/K$  ↓moles gas ↓

~~b) $\Delta S° = (197.7 + 130.7) - (5.7 J/K + 188.8 J/K = 133.9$ mols of gas ↑~~

d) $\Delta S° = [2(70.0) + 2(248.2)] - [2(205.8) + 3(205.2)] = -390.8 J/K$  #gas ↓

59) $\Delta H° = [2(-393.5) + 4(-241.8)] - [2(-238.6) + 3(0)] = -1277 KJ$

$\Delta S° = [2(213.8) + 4(188.8)] - [2(126.8) - 3(205.2)] = 313.6 J/K$

$\Delta G = -1277 KJ - (298 K)(0.316 KJ/K) = -1370. KJ$ spons

61a) $\Delta S° = [2(240.1) - (304.4)] = 0.1758 KJ$

$\Delta H° = [2(33.2) - (9.16)] = 57.2 KJ$  $\Delta G = 57.2 - ((298 K)(0.1758 KJ/K) = 4.9 KJ$

63)a) $\Delta G° =$ ~~prod - react~~  $[2(51.3)] - [99.8] = 2.8 KJ$ ← Non ? ↑T for spont

61) c) $\Delta H° = [2(0) + 3(-241.8)] - [3(0) + (-824.2)] = 98.8 KJ$

$\Delta S° = [2(27.3) + 3(188.8)] - [3(130.7) + (87.4)] = 141.5 J/K = 0.1415 KJ/K$

$\Delta G° = 98.8 KJ - (298)(0.1415 KJ/K) = 56.6 KJ$ Non ↑↑

63) c) $\Delta G° = [(-95.3) + (-16.4)] - [202.9] = 91.2 KJ$ Non

61 d) $\Delta H° = [2(-45.9)] - [0 + 0] = -91.8 KJ$

$\Delta S° = [2(192.8)] - [(191.6) + 3(130.7)] = -198.1 J/K$

$\Delta G° = -91.8 KJ - (298)(-0.1981 KJ/K) = -32.8 KJ$ spont at room T

+59

$\Delta H$ dominates  so run is spontaneous  as T↑ T$\Delta S$ term ↑ and reaction is Non spont

63 d) $\Delta G° = [2(-16.4)] - [0 + 0] = -32.8 KJ$

65 b+c) $\Delta H° = [2(33.2)] - [2(91.3) + 0] = -116.2 KJ$

$\Delta S° = [2(240.1)] - [2(210.8) + (205.2)] = -0.1466 KJ/K$

b vs) $\Delta G° = -116.2 - (715)(-0.1466) = -11.4 KJ$ spont

$\Delta G° =$  "  $-(855)$  "  $= 9.1 KJ$ Non

69) a) $I_2(s) \rightarrow I_2(g)$   $\Delta G° = [19.3] - 0 = +19.3 KJ$  non spont

b) $\Delta G_{rxn} = \Delta G° + RT \ln Q = 19.3 KJ + \left(\frac{8.314 J}{K \cdot mol}\right)\left(\frac{1KJ}{1000J}\right)(298K) \ln(0.00132)$

i)   $Q = P_{I_2}$

$1.00 mmHg * \frac{1 atm}{760} = 0.00132 atm$

$= +2.9 KJ$  Non

ii) $0.100 mmHg \times \frac{1}{760} = 0.000132 atm$    $\Delta G_{rxn} = -2.9 KJ$ spont
(at lower P)

c) sublimes at room temp due to equilibrium betw S+g phases  vapor pressure is low $(0.31 mmHg @ 25°C \rightarrow 0.00041 atm) \rightarrow \Delta G_{rxn} \approx 0$  small amt of iodine can be in gas phase

71) $\Delta G° = [(-137.2) + 2(0)] - [-162.3] = 25.1 KJ$    $Q = \frac{(0.125)(0.183)^2}{0.855} = 0.0004896$

$\Delta G_{rxn} = \Delta G° + RT \ln Q = 25.1 KJ + \left(\frac{8.314 J}{K \cdot mol}\right)\left(\frac{1KJ}{1000J}\right)(298K) \ln\left(\smile\right)$  NON
$= 11.9 KJ$

73) $\Delta G° = [2(-394.4)] - [2(-137.2) + 0] = -514.4 KJ$    $\frac{-(-0.5144 J)}{\left(8.314 J/_{K \cdot mol}\right)(298K)}$

a)  $\Delta G°_{rxn} = -RT \ln K$    $K = e^{-\frac{\Delta G°_{rxn}}{RT}} = e$

$\Delta G°$ is very large (-) magnitude    $e^{207.6} = 1.48 \times 10^{90}$

so  so K is very large ↑

b) $\Delta G° = +146.5 KJ$    $K = e^{\frac{-0.1465}{(8.314)(298)}} = 2.09 \times 10^{-26}$    $\Delta G°$ positive large so K very small

standard
75) a) $\Delta G° = -RT \ln K = -(8.314)\left(\frac{1}{1000}\right)(298) \ln(2.26 \times 10^4) = -24.8 KJ$

b) @ equilibrium $\Delta G_{rxn} = 0$

c) $Q = \frac{P_{CH_3OH}}{P_{CO}(P_{H_2})^2} = \frac{(1.0)}{(0.010)(0.010)^2} = 1.0 \times 10^6$

$\Delta G_{rxn} = \Delta G° + RT \ln Q = -24.8 + \left(\frac{8.314}{1000}\right)(298) \ln(1.0 \times 10^6)$

$= +9.4 KJ$

definition
$K > 0$ so @ standard we expect (-) $\Delta G°$  @ Equil $\Delta G° = 0$

since $Q > K$ rxn must reverse    others?