

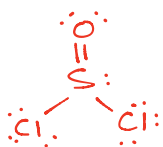


5g P      4L  
1.4 atm  
212 °C

$$\frac{5g P}{30.97g/mol} \times \frac{2 mol PH_3}{2 mol P} \times \frac{36.0g}{mol} = 5.81g PH_3$$

$$n = \frac{PV}{RT} = \frac{4L(1.4atm)}{0.08206 \frac{Latm}{mol \cdot K} \cdot (212 + 273.15)} = 0.1407 mol H_2 \times \frac{2 mol PH_3}{5 mol H_2} \times \frac{36.0g}{mol} = 2.07g$$

$H_2$  is L.R., so no moles gas left.  $P = 0 atm$



a. L.P. Oxygen = 2  
Sulfur = 1  
Chlorine = 3

b. Oxygen =  $sp^2$   
Sulfur =  $sp^3$   
Chlorine =  $sp^3$

c. Trigonal Pyramidal      d. Polar, so LDF + Dipole/Dipole

e. liquid + solid. Phases that are held together by Intermolecular forces

③ Electronegativity = the ability of an atom to attract an  $e^-$  toward itself while in a covalent bond. It is the basis/foundation of bond + molecule polarity.

EN is very similar to Electron Affinity + the opposite of Ionization energy. Atoms with high E.A. + high IE will have large Electronegativity. Fluorine has both.

④ a)  $\frac{3.2L}{L} \times \frac{265 mmol}{1 mmol} \times \frac{10^{-3} mol}{1 mmol} = 0.848 mol Na_2SO_4 \times \frac{141.98g}{mol} = 120.4g$   
dissolved in 3.2L of  $H_2O$

b) need  $0.848 mol Na_2SO_4 \times \frac{L}{2.5 mol} = 0.3392 L$  of 2.5 M needed

add 0.3392 L of the 2.5 M solution + dilute to 3.2 L  
(So add  $3.2 - 0.3392 = 2.8608 L H_2O$ )

$$\frac{0.5034}{0.00403} = \frac{k}{k} \left(\frac{0.5}{0.1}\right)^a \left(\frac{0.5}{0.5}\right)^b \left(\frac{0.1}{0.1}\right)^c$$

$$124.5 = 5^a$$

$$2.1 = a \log 5$$

$$a = 3$$

$$\frac{0.00403}{0.0000327} = \frac{k}{k} \left(\frac{0.1}{0.1}\right)^a \left(\frac{0.5}{0.1}\right)^b \left(\frac{0.1}{0.1}\right)^c$$

$$125 = 5^b$$

$$b = 3$$

$$\frac{0.00403}{0.00403} = \frac{k}{k} \left(\frac{0.1}{0.1}\right)^a \left(\frac{0.5}{0.5}\right)^b \left(\frac{0.1}{0.5}\right)^c$$

$$c = 0$$

$$0.5034 = k (0.5)^3 (0.5)^3 (0.1)^0$$

$$k = 32.22 \text{ mM}^{-4} \text{ min}^{-1}$$

$$\text{rate} = 32.22 [A]^3 [B]^3 [C]^0$$

$$\text{rate} = 32.22 \text{ mM}^{-1} \text{ min}^{-1} (0.25 \text{ mM})^3 (0.25 \text{ mM})^3 (0.25 \text{ mM})^0$$

$$\text{rate} = 7.87 \times 10^{-3} \frac{\text{mM}}{\text{min}}$$

$$6a. K = \frac{[CO][H_2]^3}{[CH_4][H_2O]}$$

$$K = \frac{(5.55 \times 10^{-3})(2.192 \times 10^{-2})^2}{(2.96 \times 10^{-3})(8.04 \times 10^{-3})}$$

$$K = 2.46 \times 10^{-3} \text{ M}^2$$

$$[CO] = 5.55 \text{ mM CO} = 5.55 \times 10^{-3} \text{ M}$$

$$[CH_4] = 2.96 \text{ mM} = 2.96 \times 10^{-3} \text{ M}$$

$$[H_2] = 21.92 \text{ mM} = 2.192 \times 10^{-2} \text{ M}$$

$$[H_2O] = 8.04 \text{ mM} = 8.04 \times 10^{-3} \text{ M}$$

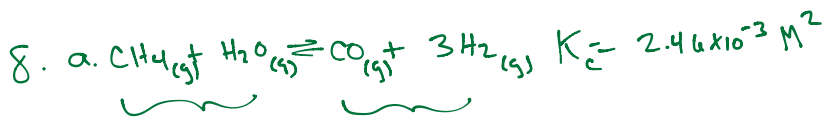
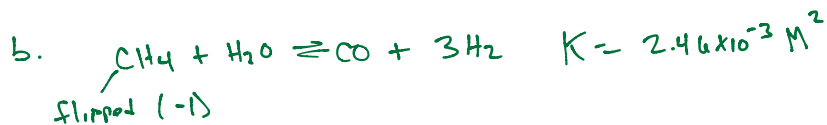
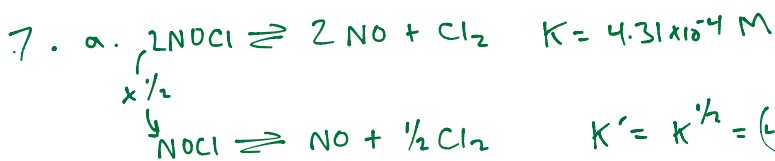
$$b. K = \frac{[NO]^2 [Cl_2]}{[NOCl]^2} = \frac{(2.88 \times 10^{-3} \text{ M})^2 (4.83 \times 10^{-3} \text{ M})}{(9.64 \times 10^{-3} \text{ M})^2}$$

$$K = 4.31 \times 10^{-4} \text{ M}$$

$$[NOCl] = 9.64 \times 10^{-3} \text{ M}$$

$$[Cl_2] = 4.83 \times 10^{-3} \text{ M}$$

$$[NO] = 2.88 \times 10^{-3} \text{ M}$$

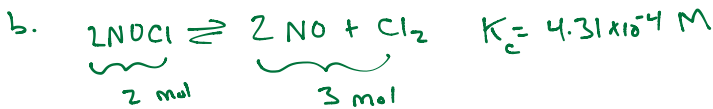


2 moles                      4 moles

$$\Delta n_{\text{gas}} = 4 - 2 = 2$$

$$K_p = K_c (RT)^{\Delta n_{\text{gas}}} = 2.46 \times 10^{-3} \text{ M}^2 (0.08206 \cdot 523.15 \text{ K})^2$$

$$K_p = 4.527 \text{ atm}^2$$



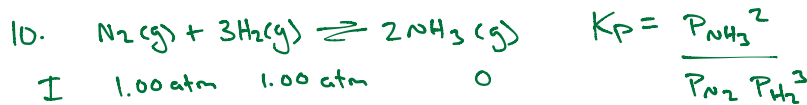
$$\Delta n_{\text{gas}} = 3 - 2 = 1$$

$$K_p = 4.31 \times 10^{-4} \text{ M} (0.08206 \cdot 523.15 \text{ K})^1 = 1.95 \times 10^{-2} \text{ atm}$$

9 If we correlate % yield with the amount of products formed, we would expect large K values to generate more product, hence higher % yield

a.  $K_c = 10^4$

b.  $K_p = 268$



I    1.00 atm    1.00 atm    0

C    -x            -3x            +2x

E    1-x        1-3x        2x

$P_{\text{N}_2}$ 
 $P_{\text{H}_2}$ 
 $P_{\text{NH}_3}$

$$P_{\text{tot}} = P_{\text{H}_2} + P_{\text{N}_2} + P_{\text{NH}_3}$$

$$1.393 \text{ atm} = (1-x) + (1-3x) + 2x$$

$\downarrow$  0.6965 atm
 $\downarrow$  0.0895 atm
 $\downarrow$  0.607 atm

$$1.393 \text{ atm} = 2 - 4x + 2x = 2 - 2x$$

$$x = 0.3035 \text{ atm}$$

$$K_p = \frac{(0.607 \text{ atm})^2}{(0.6965 \text{ atm})(0.0895 \text{ atm})^3} = 737.88 \text{ atm}^{-1}$$

b.  $P_{\text{tot}} = 1.924 \text{ atm} = 2 - 2x$

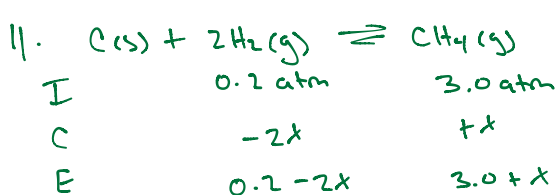
$$x = 0.038$$

$$P_{\text{H}_2} = 1 - 3x = 0.886 \text{ atm}$$

$$P_{\text{N}_2} = 1 - x = 0.962 \text{ atm}$$

$$P_{\text{NH}_3} = 2x = 0.076 \text{ atm}$$

$$K_p = \frac{(0.076 \text{ atm})^2}{(0.886 \text{ atm})^3 (0.962 \text{ atm})} = 8.63 \times 10^{-3} \text{ atm}^{-1}$$



$$K_p = 2.69 \times 10^3 \text{ atm}^{-1}$$

$$Q = \frac{3 \text{ atm}}{(0.2 \text{ atm})^2} = 75$$

$K > Q$  ... products favored

$$2.69 \times 10^3 = \frac{3.0 + x}{(0.2 - 2x)^2} = \frac{3 + x}{0.04 - 0.8x + 4x^2}$$

$$107.6 - 2152x + 10760x^2 = 3 + x$$

$$0 = 10760x^2 - 2153x + 104.6$$

$$a = 10760$$

$$b = -2153$$

$$c = 104.6$$

$$x = \frac{+2153 \pm \sqrt{(2153)^2 - 4(10760)(104.6)}}{2(10760)}$$

$$x = -0.117 \text{ or } 0.083 = x$$

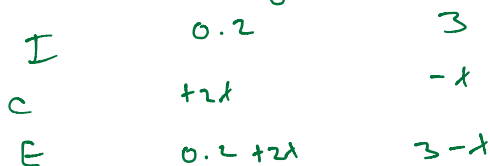
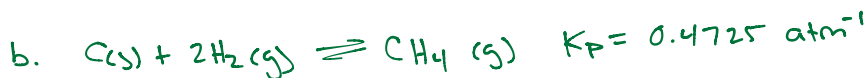
$$P_{H_2} = 0.2 - 2(0.083)$$

$$P_{H_2} = 0.2 - 2(0.117) = \text{negative... not ok}$$

$$P_{H_2} = 0.0337 \text{ atm}$$

$$11. P_{tot} = 0.0337 + 3.083 = 3.1229 \text{ atm}$$

$$P_{CH_4} = 3 + x = 3.083 \text{ atm}$$



$$Q = \frac{3}{(0.2)^2} = 75$$

$K < Q$  Reactants form!

$$0.4725 = \frac{3 - x}{(0.2 + 2x)^2} = \frac{3 - x}{0.04 + 0.8x + 4x^2}$$

$$0 = 1.89x^2 + 1.378x - 2.9811$$

$$x = \frac{-1.378 \pm \sqrt{(1.378)^2 - 4(1.89)(-2.9811)}}{2(1.89)}$$

$$x = -1.67 \text{ Not possible}$$

or

$$x = 0.943$$

$$P_{H_2} = 0.2 + 2x = 0.2 + 2(0.943) = 2.0863 \text{ atm}$$

$$P_{CH_4} = 3 - x = 3 - 0.943 = 2.0568 \text{ atm}$$

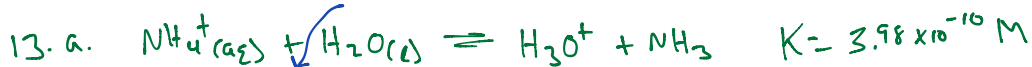
$$11. P_{tot} = 2.0863 + 2.0568$$

$$P_{tot} = 4.1431 \text{ atm}$$

$$\text{CHECK: } \frac{2.0568}{(2.0863)^2} = 0.4725 \text{ atm}^{-1} \checkmark$$

12. See above

make sure to use M, not mM!



I	$1 \times 10^{-3} \text{ M}$	0	0
C	$-x$	$+x$	$+x$
E	$1 \times 10^{-3} - x$	$x$	$x$

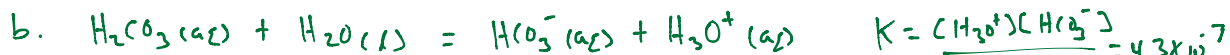
$$3.98 \times 10^{-10} = \frac{x^2}{1 \times 10^{-3} - x}$$

$$3.98 \times 10^{-13} - 3.98 \times 10^{-10} x = x^2$$

$$0 = x^2 + 3.98 \times 10^{-10} x - 3.98 \times 10^{-13}$$

$$x = 6.307 \times 10^{-7} \text{ M} = [\text{H}_3\text{O}^+]$$

$$x = \cancel{-6.31 \times 10^{-7}}$$



I	0.5	0	0
C	$-x$	$+x$	$+x$
E	$0.5 - x$	$x$	$x$

$$4.3 \times 10^{-7} = \frac{x^2}{0.5 - x}$$

$$2.15 \times 10^{-7} - 4.3 \times 10^{-7} x = x^2$$

$$0 = x^2 + 4.3 \times 10^{-7} x - 2.15 \times 10^{-7}$$

$$x = 4.635 \times 10^{-4} \text{ M} = [\text{H}_3\text{O}^+]$$

$$x = \cancel{-4.64 \times 10^{-4}}$$

$$14. Q = \frac{P_{N_2} P_{H_2}^3}{P_{NH_3}^2}$$

$$a. Q = 83.4$$

$K = Q$  Equilibrium

$$b. Q = 5192$$

$K > Q$  Products form

$$c. Q = 122.5$$

$K < Q$  Reactants form

15. Vapor pressure refers to the evaporation equilibrium:



$$a. K_p = \text{vapor pressure} = \frac{92.5876 \text{ mmHg}}{760 \text{ mmHg}} \Bigg| \frac{1 \text{ atm}}{760 \text{ mmHg}}$$

$$K_p = P_{H_2O(g)}$$

so  $K_p = \text{vapor pressure!}$

$$P_{H_2O} = 0.1218 \text{ atm}$$

$$b. K_p = P_{H_2O} = \frac{38.5630 \text{ kPa}}{1 \text{ kPa}} \Bigg| \frac{10^5 \text{ Pa}}{1 \text{ kPa}} \Bigg| \frac{1 \text{ atm}}{101325 \text{ Pa}} = 0.381 \text{ atm}$$

16. a. heat is a product (exothermic), so  $\uparrow$  Temp would cause **reactants** to form

b. Volume influences pressure of gases. Since the moles of gas are the same on both sides, **no change** will be observed

c. Solids don't influence the equilibrium  $\rightarrow$  **no change**

d. Solids don't influence the equilibrium  $\rightarrow$  **no change**

e. Product added, so **reactants** form

f. reactant added, **products** form

g.  $Q = \frac{850 \text{ atm}}{2 \text{ atm}} = 425$        $K > Q$       **products form**

h.  $Q = \frac{0.8 \text{ atm}}{5 \text{ atm}} = 0.16$        $K < Q$       **reactants form**

17. If products are favored,  $\Delta G < 0$

If reactants are favored,  $\Delta G > 0$

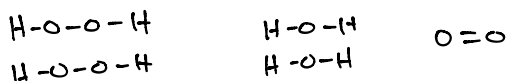
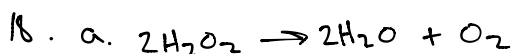
If no change,  $\Delta G = 0$

a.  $\Delta G > 0$       b.  $\Delta G = 0$

c.  $\Delta G = 0$       d.  $\Delta G = 0$

e.  $\Delta G > 0$       f.  $\Delta G < 0$

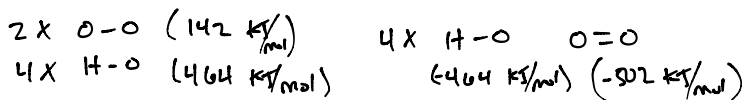
g.  $\Delta G < 0$       h.  $\Delta G > 0$



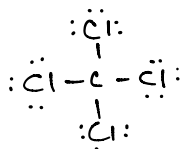
$\Delta H_{\text{rxn}}^\circ = -502 + 4(-464) + 4(464) + 2(142)$

$\Delta H_{\text{rxn}}^\circ = -218 \text{ kJ/mol}$

exothermic  $\rightarrow$  **favorable**



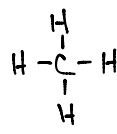
b.



$4 \times \text{C}-\text{C}$   
 $331 \text{ kJ/mol}$



$2 \times \text{H}-\text{H}$   
 $435 \text{ kJ/mol}$

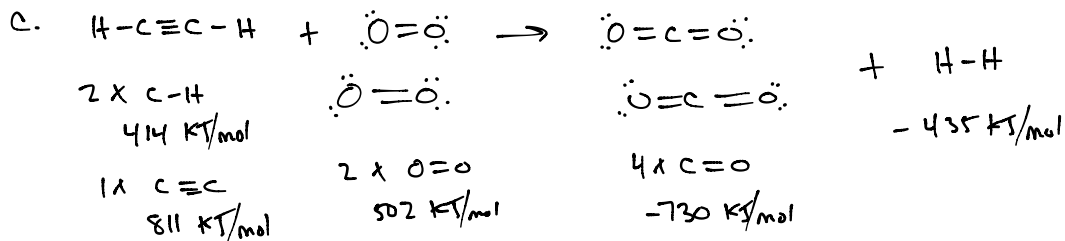


$4 \times \text{C}-\text{H}$   
 $-414 \text{ kJ/mol}$

$\Delta H_{\text{rxn}}^\circ = 4(331) + 2(435) + 4(-414)$

$\Delta H_{\text{rxn}}^\circ = 470 \text{ kJ/mol}$

endothermic: **NOT favorable**



$$\Delta H_{\text{rxn}}^{\circ} = 811 + 2(414) + 2(502) + 4(-730) - 435 = -712 \text{ kJ/mol}$$

favorable

19. a. exothermic  $\rightarrow$  as  $T \uparrow$ ,  $K \downarrow$   
 $K_{100} > K_{250}$

b. endothermic  
 $K_{250} > K_{100}$

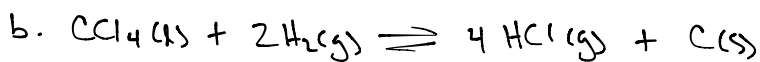
c. exothermic  
 $K_{100} > K_{250}$



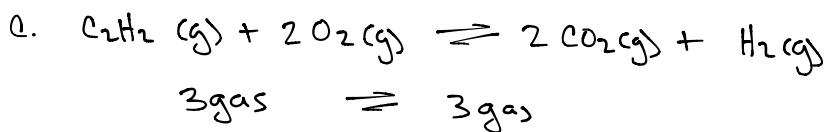
more gas in the products, so entropy increase ( $\Delta S > 0$ )

$$\Delta S_{\text{rxn}}^{\circ} = 131.4 \text{ J/mol}$$

from  $\Delta S^{\circ}$



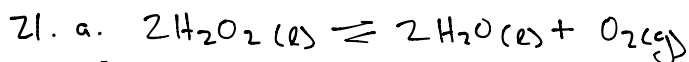
more gas in the products, so entropy increase ( $\Delta S > 0$ )



$$\Delta S_{\text{rxn}}^{\circ} = 179.9 \text{ J/mol}$$

from  $S^{\circ}$

Not able to determine



$\Delta H_f^{\circ}$	-187.8	-285.8	0
$S^{\circ}$	109.6	70.0	205.2
$\Delta G_f^{\circ}$	-120.4	-237.1	0

$$\Delta H_{\text{rxn}}^{\circ} = 2(-285.8) - (2(-187.8))$$

$$\Delta H_{\text{rxn}}^{\circ} = -196 \text{ kJ/mol}$$

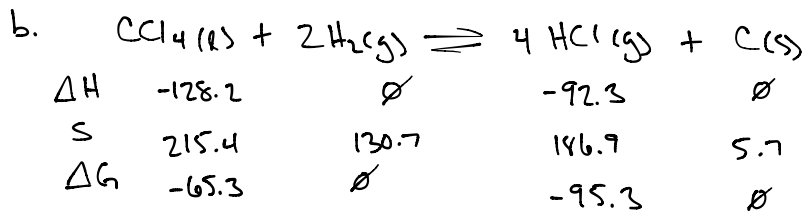
$$\Delta S_{\text{rxn}}^{\circ} = 205.2 + 2(70) - 2(109.6)$$

$$\Delta S_{\text{rxn}}^{\circ} = 126 \text{ J/mol K}$$

$$\Delta G_{\text{rxn}}^{\circ} = 2(-237.1) - 2(-120.4)$$

$$\Delta G_{\text{rxn}}^{\circ} = -233.4 \text{ kJ/mol}$$

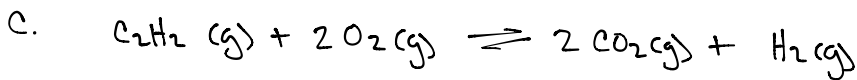




$$\Delta H_{\text{rxn}}^{\circ} = 4(-92.3) - (-128.2) = -241 \text{ kJ/mol}$$

$$\Delta S_{\text{rxn}}^{\circ} = 4(186.9) + 5.7 - 215.4 - 2(130.7) = 276.5 \text{ J/mol}\cdot\text{K}$$

$$\Delta G_{\text{rxn}}^{\circ} = 4(-95.3) - (-65.3) = -315.9 \text{ kJ/mol}$$



$\Delta H$	227.4	0	-393.5	$\emptyset$
S	200.9	205.2	213.8	130.7
$\Delta G$	209.9	0	-394.4	$\emptyset$

$$\Delta H_{\text{rxn}}^{\circ} = 2(-393.5) - 227.4 = -1014.4 \text{ kJ/mol}$$

$$\Delta S_{\text{rxn}}^{\circ} = 2(213.8) + 130.7 - 200.9 - 2(205.2) = -53 \text{ J/mol}\cdot\text{K}$$

$$\Delta G_{\text{rxn}}^{\circ} = 2(-394.4) - 209.9 = -998.7 \text{ kJ/mol}$$

22. a.  $\Delta G^{\circ} = -RT \ln K = \frac{-8.314 \text{ J}}{\text{mol}\cdot\text{K}} (298.15 \text{ K}) \ln 1.1 \times 10^5 = -28,774.7 \text{ J/mol}$

b.  $\Delta G^{\circ} = \frac{-8.314 \text{ J}}{\text{mol}\cdot\text{K}} (298.15 \text{ K}) \ln 1.32 \times 10^{-25} = 142,004 \text{ J/mol} = 142 \text{ kJ/mol}$

23. a.  $\Delta G = \Delta G^{\circ} + RT \ln Q$

$$\Delta G = \frac{-28,774.7 \text{ J}}{\text{mol}} + 8.314 (273.15 + 75) \ln \frac{0.1}{(0.1)(0.5)} = -26,768 \text{ J/mol}$$

$$\Delta G = -26.77 \text{ kJ/mol}$$

b.  $\Delta G = 142,004 \text{ J/mol} + 8.314 (273.15 + 75) \ln \frac{(0.002)^2 (0.0001)}{(0.008)^2} = 107,319 \text{ J/mol}$

$$\Delta G = 107.3 \text{ kJ/mol}$$

24. Need to use both  $\Delta G^\circ = -RT \ln K$   $A \rightarrow B$   $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$

a.  $\Delta G^\circ = -RT \ln K = -8.314 (298.15) \ln 3.03 \times 10^{-7}$

$$\Delta G^\circ_{rxn} = 37,206 \text{ J/mol}$$

$$\Delta G = \Delta H - T\Delta S$$

$$\Delta S = \frac{-\Delta G + \Delta H}{T} = \frac{-37,206 + 87,900}{298.15} = 170.0 \text{ J/mol K}$$

b.  $\Delta G^\circ = -8.314 (298.15) \ln 1.32 \times 10^{-25} = 142,004 \text{ J/mol}$

$$\Delta S^\circ = \frac{-\Delta G^\circ + \Delta H^\circ}{T} = \frac{-142,000 + 197,800}{298.15} = 187.1 \text{ J/mol K}$$

25. a. Se b/c bigger (same phase, so bigger molecule has larger  $S^\circ$ )

b.  $\text{H}_2\text{O}(\text{g})$  gas

c.  $\text{H}_2\text{S}(\text{l}) \rightarrow$  bigger

26.  $E_a$  is the difference between reactants and the transition state (T). Minimizing this maximizes  $k$  ( $k = A e^{-E_a/RT}$ )  $k_2 > k_1$

$\Delta G = -RT \ln K$ , so the bigger the difference between reactants (both are  $\Delta G < 0$ ), the bigger  $K$  will be

$$K_2 > K_1$$

Answer d is correct

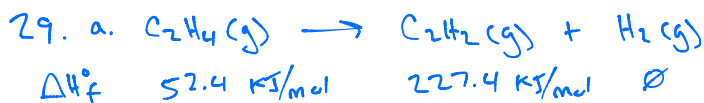
27. a.  $l \rightarrow s$   $\Delta H < 0$  exothermic  
 b.  $g \rightarrow l$   $\Delta H < 0$  exothermic  
 c.  $s \rightarrow l$   $\Delta H > 0$  endothermic  
 d.  $l \rightarrow g$   $\Delta H > 0$  endothermic  
 e.  $s \rightarrow g$   $\Delta H > 0$  endothermic

28. Strength of Intermolecular force is important. Stronger IMF, more energy is needed to convert  $s \rightarrow l$  or  $l \rightarrow g$

- a. HF: H-bond, dipole, LDF      HCl: dipole + LDF  
 F<sub>2</sub>: LDF + smaller than Cl<sub>2</sub>      Cl<sub>2</sub>: LDF + bigger than F<sub>2</sub>



- b. NH<sub>3</sub>: H-bond, dipole, LDF      NCl<sub>3</sub>: non-polar: LDF only!  
 PCl<sub>3</sub>: polar: dipole + LDF



$$\Delta H_{rxn}^\circ = 227.4 \text{ kJ/mol} - 52.4 \text{ kJ/mol} = 175 \text{ kJ/mol}$$



$\Delta H_f^\circ$     -92.3    -74.6    -128.2    0  
 (all in kJ/mol)

$$\Delta H_{rxn}^\circ = -128.2 \text{ kJ/mol} - (4(-92.3 \text{ kJ/mol}) + -74.6 \text{ kJ/mol}) = 315.6 \text{ kJ/mol}$$



$V = 2.8 \text{ L}$

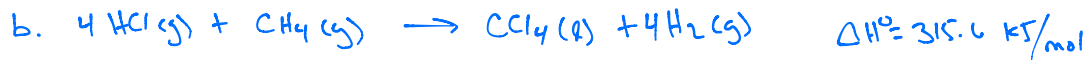
$T = 200^\circ\text{C} + 273.15 = 473.15 \text{ K}$

$P = 2.8 \text{ atm}$

$$n_{C_2H_4} = \frac{PV}{RT} = \frac{2.8 \text{ atm}(2.8 \text{ L})}{(0.08206)(473.15 \text{ K})} = 0.202 \text{ mol}$$

$$\frac{0.202 \text{ mol } C_2H_4 \mid 67}{100} = 0.1352 \text{ mol } C_2H_4 \text{ used up}$$

$$\frac{0.1352 \text{ mol } C_2H_4 \mid 175 \text{ kJ}}{1 \text{ mol } C_2H_4} = 23.68 \text{ kJ}$$



remember:  $\Delta H_f^\circ = \frac{315.6 \text{ kJ}}{4 \text{ mol HCl}} = \frac{315.6 \text{ kJ}}{1 \text{ mol CH}_4} = \frac{315.6 \text{ kJ}}{1 \text{ mol CCl}_4} = \frac{315.6 \text{ kJ}}{4 \text{ mol H}_2}$

$$\text{HCl: } n = \frac{PV}{RT} = \frac{5.5 \text{ L}(1.908 \text{ atm})}{0.08206(212+273.15)} = \frac{0.264 \text{ mol HCl} \mid 1 \text{ mol CCl}_4}{4 \text{ mol HCl}} = 0.0659$$

$$\text{CH}_4: n = \frac{PV}{RT} = \frac{5.5 \text{ L}(0.602 \text{ atm})}{0.08206(273.15+212)} = \frac{0.0832 \text{ mol} \mid 1 \text{ mol CCl}_4}{1 \text{ mol CH}_4} = 0.0832 \text{ mol}$$

HCl is L.R.!

$$\frac{0.264 \text{ mol HCl} \mid 315.6 \text{ kJ}}{4 \text{ mol HCl}} = 20.8296 \text{ kJ}$$

31. Greatest impact on  $U_{sys}$ . So we're looking for the biggest  $\Delta U$ !

$\Delta U = z + w = z - P\Delta V$  This problem gives no info about heat change, so we're just looking for the largest work term!

a.  $w = -P\Delta V$

i.  $w = -0.2 \text{ L} (1 \text{ atm})$   
 $w = -0.2 \text{ L} \cdot \text{atm}$

ii.  $w = -0.3 \text{ L} (0.75 \text{ atm})$  by the way, did you know that this is a unit of energy??

$w = -0.225 \text{ L} \cdot \text{atm}$   
 bigger change!

$PV = \text{energy} = nRT$   
 so this is also energy!

b. i.  $w = 0.5 \text{ L} (4 \text{ atm}) = 2 \text{ L} \cdot \text{atm}$

ii.  $w = 1 \text{ L} (2.5 \text{ atm}) = 2.5 \text{ L} \cdot \text{atm}$  bigger change

32. ethanol (l)  $\rightleftharpoons$  ethanol (g)  $K_p = P_{\text{ethanol}}$  Vapor Pressure =  $K_p$ !

$$\ln \frac{K_2}{K_1} = -\frac{\Delta H}{R} \left( \frac{1}{T_2} - \frac{1}{T_1} \right)$$

$K_1$  &  $K_2$  are vapor pressures  
 @ given temp      @  $T_b$ ,  $K_2 = 1.00 \text{ atm}$  (760 mmHg)

a.  $T_1 = 34.9^\circ\text{C} + 273.15 \text{ K} = 308.05 \text{ K}$   
 $T_2 = ?$

$\Delta H = 38.56 \text{ kJ/mol} = 38560 \text{ J/mol}$

$K_1 = 100 \text{ mmHg}$   
 $K_2 = 760 \text{ mmHg}$

$$\ln \frac{760}{100} = -\frac{38560 \text{ J/mol}}{8.314 \text{ J/mol} \cdot \text{K}} \left( \frac{1}{T_2} - \frac{1}{308.05} \right)$$

$$2.028 = -4637.96 \left( \frac{1}{T_2} - 3.246 \times 10^{-3} \right)$$

$$-4.373 \times 10^{-4} \text{ K}^{-1} = \frac{1}{T_2} - 3.246 \times 10^{-3} \text{ K}^{-1}$$

$$\frac{1}{T_2} = 2.809 \times 10^{-3} \text{ K}^{-1}$$

$T_2 = 356.03 \text{ K}$

b.  $\Delta H = 31300 \text{ J/mol}$   
 $K_1 = 400 \text{ mmHg}$   
 $K_2 = 760 \text{ mmHg}$   
 $T_1 = 312.65 \text{ K}$   
 $T_2 = ?$

$$\ln \frac{760}{400} = -\frac{31300}{8.314} \left( \frac{1}{T_2} - \frac{1}{312.65} \right)$$

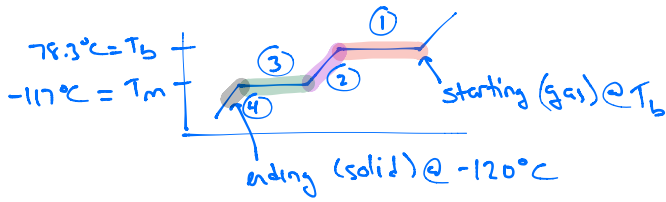
$$0.6419 = -3764 \left( \frac{1}{T_2} - 3.198 \times 10^{-3} \right)$$

$$-1.4178 \times 10^{-3} = \frac{1}{T_2} - 3.198 \times 10^{-3}$$

$$\frac{1}{T_2} = 1.7803 \times 10^{-3}$$

$T_2 = 561.72 \text{ K}$

33. a.



$$\frac{140\text{g}}{46.082\text{g}} = 3.038\text{ mol}$$

4 steps!

$$\textcircled{1} \Delta H = 3.038\text{ mol} \left| \frac{-38.57\text{ kJ}}{\text{mol}} \right. = -117.18\text{ kJ}$$

$$\textcircled{2} \Delta H = 3.038\text{ mol} \left| \frac{112.4\text{ J}}{\text{mol} \cdot ^\circ\text{C}} \right. (-117 - 78.3) = -66,689\text{ J} = -66.7\text{ kJ}$$

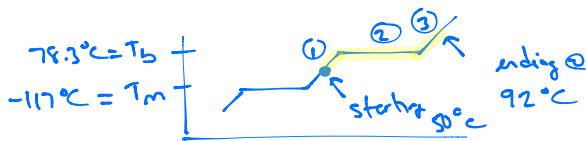
$$\textcircled{3} \Delta H = 3.038\text{ mol} \left| \frac{-5.02\text{ kJ}}{\text{mol}} \right. = -15.25\text{ kJ}$$

$$\textcircled{4} \Delta H = 3.038\text{ mol} \left| \frac{111.5\text{ J}}{\text{mol} \cdot ^\circ\text{C}} \right. (-120 - -117) = -1,016\text{ J} = -1.02\text{ kJ}$$

$$\Delta H_{\text{TOT}} = \Delta H_1 + \Delta H_2 + \Delta H_3 + \Delta H_4 = -117.18\text{ kJ} + -66.7\text{ kJ} + -15.25\text{ kJ} + -1.02\text{ kJ}$$

$$\Delta H_{\text{TOT}} = -200.15\text{ kJ}$$

b.



$$\frac{360\text{g}}{46.082\text{g}} = 7.812\text{ mol}$$

$$\Delta H_{\text{TOT}} = \Delta H_1 + \Delta H_2 + \Delta H_3$$

$$\textcircled{1} \Delta H_1 = 7.812\text{ mol} \left| \frac{112.4\text{ J}}{\text{mol} \cdot ^\circ\text{C}} \right. (78.3 - 50) = 24,849\text{ J} = 24.85\text{ kJ}$$

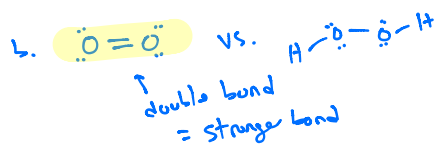
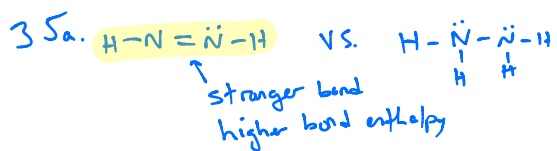
$$\textcircled{2} \Delta H_2 = 7.812\text{ mol} \left| \frac{38.57\text{ kJ}}{\text{mol}} \right. = 301.31\text{ kJ}$$

$$\textcircled{3} \Delta H_3 = 7.812\text{ mol} \left| \frac{87.55\text{ J}}{\text{mol} \cdot ^\circ\text{C}} \right. (92 - 78.3) = 9369.99\text{ J} = 9.37\text{ kJ}$$

$$\Delta H_{\text{TOT}} = 24.85\text{ kJ} + 301.31\text{ kJ} + 9.37\text{ kJ} = 335.53\text{ kJ}$$

$$34. a. \Delta S_{\text{fus}}^{\circ} = \frac{\Delta H_{\text{fus}}^{\circ}}{T_m} = \frac{9020 \text{ J/mol}}{(-117 + 273.15) \text{ K}} = 32.15 \text{ J/mol}\cdot\text{K}$$

$$b. \Delta S_{\text{vap}}^{\circ} = \frac{\Delta H_{\text{vap}}^{\circ}}{T_b} = \frac{38,570 \text{ J/mol}}{(273.15 + 78.3) \text{ K}} = 109.7 \frac{\text{J}}{\text{mol}\cdot\text{K}}$$



36. a. Total internal energy → defined as the variable  $U$ . This is the sum of ALL energy within a system → potential and kinetic

b. The First Law of Thermo → Energy is conserved!  $\Delta U_{\text{sys}} = -\Delta U_{\text{surr}} = q + w$

c. Enthalpy → the heat exchanged between the system and the surroundings @ constant  $P$   
 $\Delta H = zP$

d. Work → energy gained or lost through expansion.  $w = -P\Delta V$