

Key - Thermochemistry: Gas Laws Review (1)

1. a. heat - flow of energy due to a difference in temperature
- b. temperature - average kinetic energy of all the particles in a substance
- c. exothermic - heat is released from a substance
- d. endothermic - heat is absorbed by a substance
- e. enthalpy - amount of heat energy produced/absorbed by a chemical reaction
- f. Boyle's Law - pressure and volume are inversely proportional at constant temperature (K)

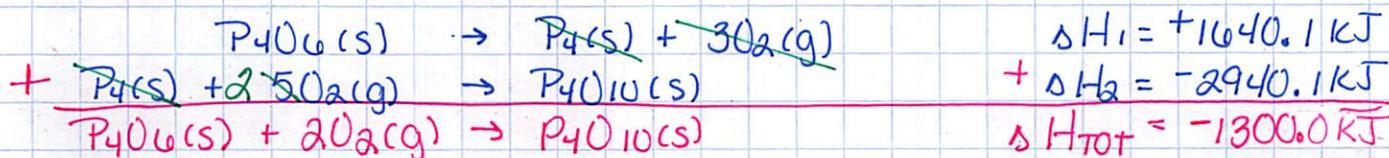
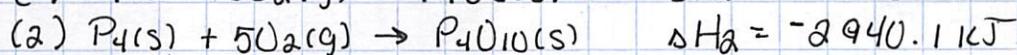
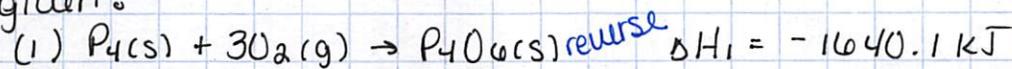
$$P_1 V_1 = P_2 V_2$$
- g. Charles's Law - volume and temperature (K) are directly proportional at constant pressure

$$V_1 T_2 = V_2 T_1$$
- h. Avogadro's Law - the number of moles (n) of a substance is directly proportional to the volume

$$n_1 V_2 = n_2 V_1$$
- i. Combined Gas Law - $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$
- j. Ideal Gas Law - $PV = nRT$ $R = 0.08206 \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}}$

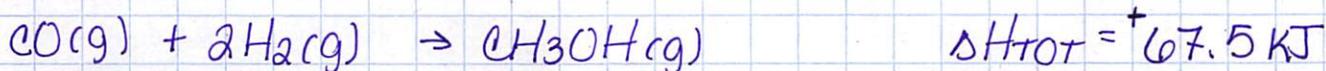
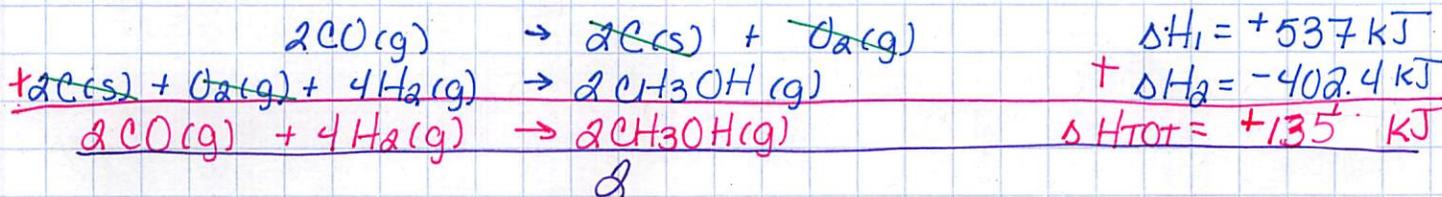
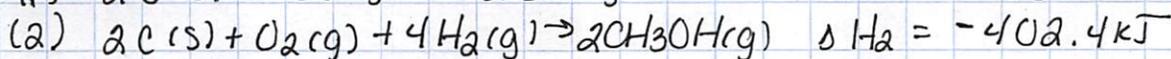
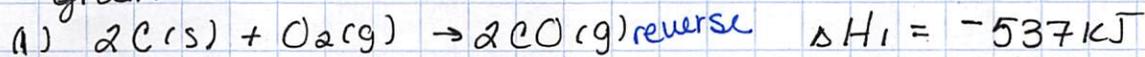
2. a. calculate ΔH for: $\text{P}_4\text{O}_6(\text{s}) + 2\text{O}_2(\text{g}) \rightarrow \text{P}_4\text{O}_{10}(\text{s})$

given:



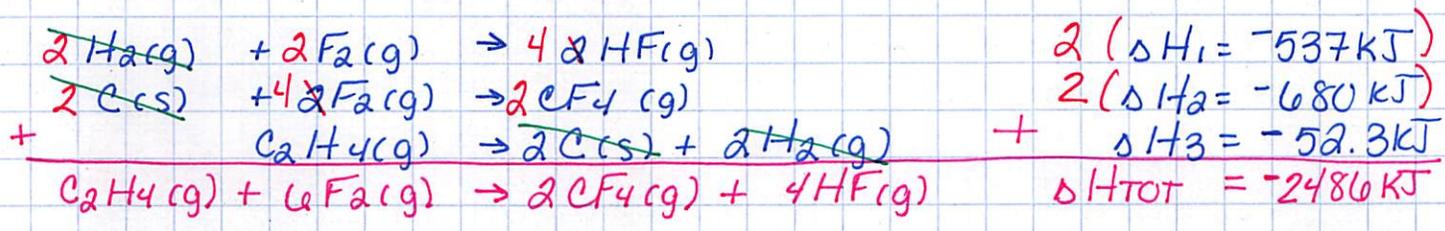
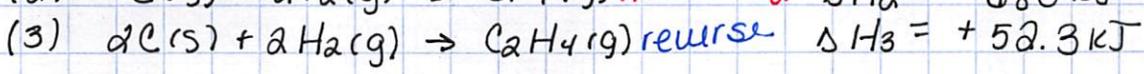
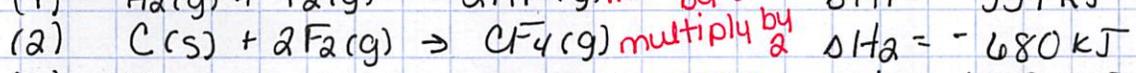
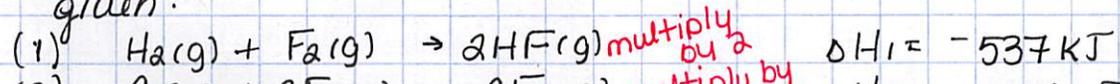
b. Calculate ΔH for: $\text{CO}(\text{g}) + 2\text{H}_2(\text{g}) \rightarrow \text{CH}_3\text{OH}(\text{g})$

given:



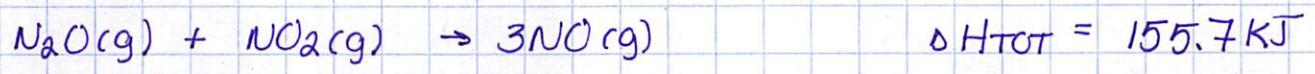
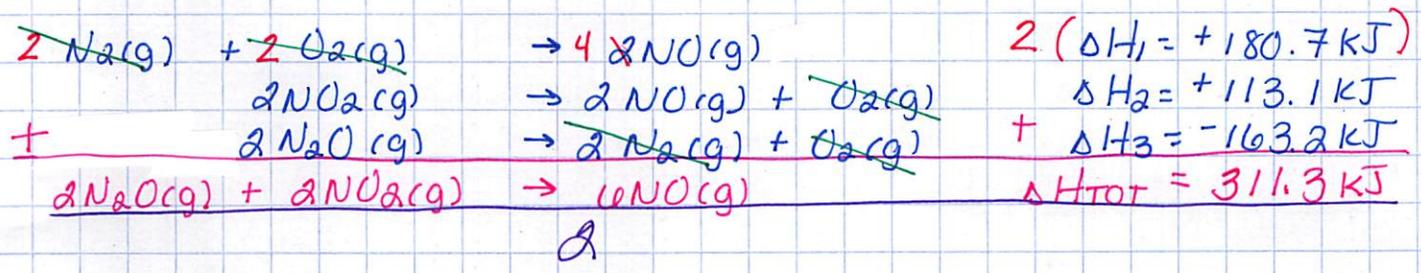
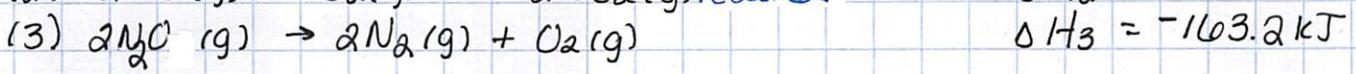
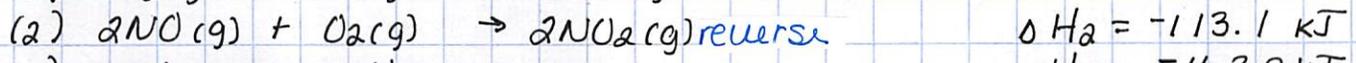
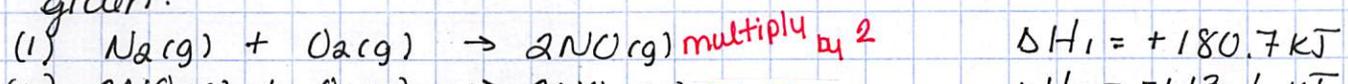
2d. Calculate ΔH for: $C_2H_4(g) + 6F_2(g) \rightarrow 2CF_4(g) + 4HF(g)$

given:



e. Calculate ΔH for: $Na_2O(g) + NO_2(g) \rightarrow 3NO(g)$

given:



3a. $q = mc\Delta T$ $\Delta T = T_f - T_i$

$q = ?$

$m = 80.0 \text{ g}$

$c = 2.22 \text{ J/gK}$

$\Delta T = 298 \text{ K} - 283 \text{ K} = 15 \text{ K}$

$q = (80.0 \text{ g})(2.22 \text{ J/gK})(15 \text{ K})$

$q = 2664 \text{ J} = \{2660 \text{ J}\}$ endothermic

b. $q = ?$

$m = 45.0 \text{ g}$

$c = .385 \text{ J/g}^\circ\text{C}$

$\Delta T = 15.0^\circ\text{C} - 30.0^\circ\text{C} = -15.0^\circ\text{C}$

$q = (45.0 \text{ g})(.385 \text{ J/g}^\circ\text{C})(-15.0^\circ\text{C})$

$q = -259.875 \text{ J} = \{-260. \text{ J}\}$ exothermic

3c. $q = -1500. J$
 $m = 99.88g$
 $C = 1.020 J/g^{\circ}C$
 $\Delta T = ?$

$-1500. J = (99.88g)(1.020 J/g^{\circ}C) \Delta T$
 $-1500. J = (101.8776 J/g^{\circ}C) \Delta T$
 $101.8776 J/g^{\circ}C \quad 101.8776 J/g^{\circ}C$

$14.72355061^{\circ}C = \Delta T$
 $14.72^{\circ}C = \Delta T$

5a. Charles's Law $V_1 T_2 = V_2 T_1$

$V_1 = 5.00L$
 $T_1 = 24.0^{\circ}C = 297K$
 $V_2 = ?$
 $T_2 = -272^{\circ}C = 1.00K$

$(5.00L)(1.00K) = V_2(297K)$
 $\frac{5.00L \cdot K}{297K} = \frac{V_2(297K)}{297K}$

$.016835017L = V_2$
 $.0168L = V_2$

b. Avogadro's Law $n_1 V_2 = n_2 V_1$

$n_1 = .214mol$
 $V_1 = 652mL$
 $n_2 = .375mol$
 $V_2 = ?$

$(.214mol) V_2 = (.375mol)(652mL)$
 $\frac{(.214mol) V_2}{.214mol} = \frac{244.5mol \cdot mL}{.214mol}$

$V_2 = 1142.523364mL$
 $V_2 = 1140mL$

c. Boyle's Law $P_1 V_1 = P_2 V_2$

$P_1 = 1.00atm$
 $V_1 = 33.0L$
 $P_2 = .562atm$
 $V_2 = ?$

$(1.00atm)(33.0L) = (.562atm) V_2$
 $\frac{33.0atm \cdot L}{.562atm} = \frac{(.562atm) V_2}{.562atm}$

$18.546L = V_2$
 $18.5L = V_2$

d. Avogadro's Law $n_1 V_2 = n_2 V_1$

$n_1 = .777mol$
 $V_1 = 1900.mL = 1.900L$
 $n_2 = ?$
 $V_2 = 1.200L$

$(.777mol)(1.200L) = n_2(1.900L)$
 $\frac{.9324mol \cdot L}{1.900L} = \frac{n_2(1.900L)}{1.900L}$

$.490736842L = n_2$ $n_2 = .491mol$

FIVE STAR. ★★★★★

e. Combined Gas Law

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$P_1 = 190.0 \text{ kPa}$

$V_1 = 1.23 \text{ L}$

$T_1 = 42.0^\circ\text{C} = 315 \text{ K}$

$P_2 = \frac{1100. \text{ torr}}{760 \text{ torr}} \cdot 101.325 \text{ kPa} = 146.7 \text{ kPa}$

$V_2 = ?$

$T_2 = 24.0^\circ\text{C} = 297 \text{ K}$

$$\frac{(190.0 \text{ kPa})(1.23 \text{ L})}{315 \text{ K}} = \frac{(146.7 \text{ kPa}) V_2}{297 \text{ K}}$$

$$\frac{.741904762 \frac{\text{kPa} \cdot \text{L}}{\text{K}}}{.493939394 \frac{\text{kPa}}{\text{K}}} = \frac{(\cancel{.493939394} \frac{\text{kPa}}{\text{K}}) V_2}{\cancel{.493939394} \frac{\text{kPa}}{\text{K}}}$$

$$\frac{.741904762 \frac{\text{kPa} \cdot \text{L}}{\text{K}}}{.493939394 \frac{\text{kPa}}{\text{K}}} = \frac{.493939394 \frac{\text{kPa}}{\text{K}} V_2}{.493939394 \frac{\text{kPa}}{\text{K}}}$$

$1.502015776 \text{ L} = V_2$
 $1.50 \text{ L} = V_2$

f. Boyle's Law

$$P_1 V_1 = P_2 V_2$$

$P_1 = .3456 \text{ atm}$

$V_1 = 1234 \text{ mL}$

$P_2 = ?$

$V_2 = 2345 \text{ mL}$

$$(.3456 \text{ atm})(1234 \text{ mL}) = P_2 (2345 \text{ mL})$$

$$\frac{426.4704 \text{ atm} \cdot \text{mL}}{2345 \text{ mL}} = \frac{P_2 (2345 \text{ mL})}{2345 \text{ mL}}$$

$.18186371 \text{ atm} = P_2$
 $.1819 \text{ atm} = P_2$

g. Charles's Law

$$V_1 T_2 = V_2 T_1$$

$V_1 = 3.00 \text{ L}$

$T_1 = 25.00^\circ\text{C} = 298.00 \text{ K}$

$V_2 = 6.00 \text{ L}$

$T_2 = ?$

$$(3.00 \text{ L}) T_2 = (6.00 \text{ L})(298.00 \text{ K})$$

$$\frac{(3.00 \text{ L}) T_2}{3.00 \text{ L}} = \frac{1788 \text{ L} \cdot \text{K}}{3.00 \text{ L}}$$

$T_2 = 596 \text{ K}$

h. Ideal Gas Law

$$PV = nRT$$

$$R = .08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}$$

$P = \frac{126.7 \text{ kPa}}{101.325 \text{ kPa}} \cdot 1 \text{ atm} = 1.25 \text{ atm}$

$V = 25.00 \text{ L}$

$n = \frac{16.3 \text{ g Na}}{28.02 \text{ g}} \cdot 1 \text{ mol} = .582 \text{ mol}$

$R = .08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}$

$T = ?$

$$(1.25 \text{ atm})(25.00 \text{ L}) = (.582 \text{ mol})(.08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}) T$$

$$31.25 \text{ atm} \cdot \text{L} = (.04775892 \frac{\text{L} \cdot \text{atm}}{\text{K}}) T$$

$$\frac{31.25 \text{ atm} \cdot \text{L}}{.04775892 \frac{\text{L} \cdot \text{atm}}{\text{K}}} = T$$

$654.3280292 \text{ K} = T$
 $T = 654 \text{ K}$

i. ideal gas law $PV = nRT$ $R = .08206 \frac{L \cdot atm}{mol \cdot K}$

$P = 726 \text{ torr} = .955 \text{ atm}$ $\frac{726 \text{ torr}}{760 \text{ torr}} \cdot 1 \text{ atm} = .955 \text{ atm}$

$V = ?$

$n = 100.0 \text{ g Kr} = 1.193 \text{ mol}$ $\frac{100.0 \text{ g Kr}}{83.80 \text{ g}} = 1.193 \text{ mol}$

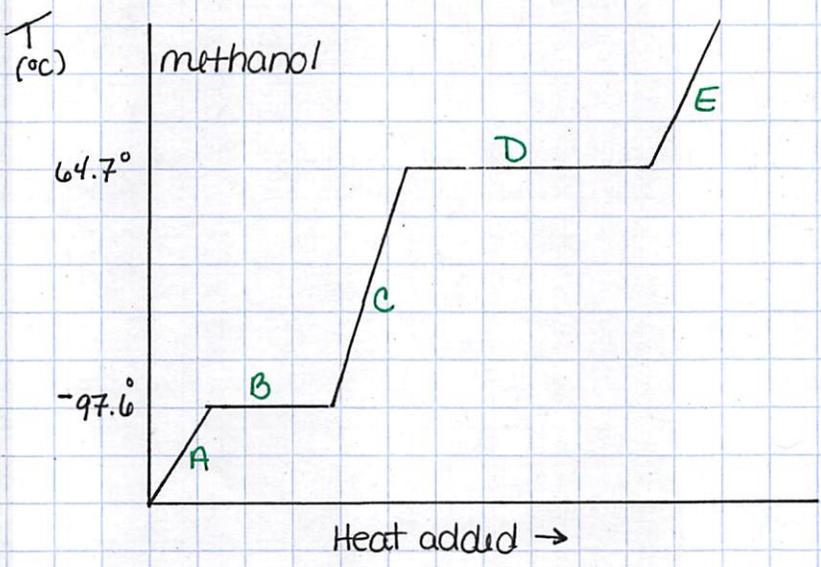
$R = .08206 \frac{L \cdot atm}{mol \cdot K}$

$T = -99.46^\circ\text{C} = 173.3 \text{ K}$

$(.955 \text{ atm}) V = (1.193 \text{ mol}) (.08206 \frac{L \cdot atm}{mol \cdot K}) (173.3 \text{ K})$
 $(.955 \text{ atm}) V = \frac{16.96565061 \text{ L} \cdot \text{atm}}{.955 \text{ atm}}$

$V = 17.8 \text{ L}$

Let's talk heating curves: we reviewed in class.



- (1) what state(s) of matter exist(s) at line segment A? SOLID
- (2) what state(s) of matter exist(s) at line segment B? why? SOLID + LIQUID, it's melting.
- (3) what state(s) of matter exist(s) at line segment C? LIQUID
- (4) what state(s) of matter exist(s) at line segment D? why? LIQUID + GAS, it's boiling.

(5) what state(s) of matter exist(s) at line segment E? GAS

(6) Describe the "job" of the heat energy being added at each line segment.

- A - Energy is increasing the temperature of the solid ($q = mc\Delta T$)
- B - Energy is weakening the IMFs so the solid will melt (ΔH_{fus})
- C - Energy is increasing the temperature of the liquid ($q = mc\Delta T$)
- D - Energy is breaking the IMFs so the liquid can escape as a gas (vaporize) (ΔH_{vap})
- E - Energy is increasing the temperature of the gas ($q = mc\Delta T$)