

**Chem 10123, Quiz 6**

March 18, 2020

**Answer Key**

1. (6 points) **SHOW ALL WORK.** A gas is compressed from an initial volume of 4.50 L to a final volume of 1.20 L by an external pressure of 2.5 atm. During the compression, the gas releases 225 J of heat. Determine the change in the internal energy of the system in joules. (1 L·atm = 101.3 J).

$$\Delta E = q + w \quad q = -225 \text{ J (heat is lost by the system)}$$

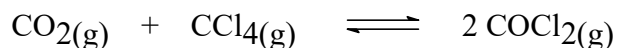
$$w = -P\Delta V = -(2.5 \text{ atm})(1.2 \text{ L} - 4.5 \text{ L}) = 8.25 \text{ L}\cdot\text{atm (work is done on the system)}$$

$$\Delta E = -225 \text{ J} + (8.25 \text{ L}\cdot\text{atm})(101.3 \text{ J/L}\cdot\text{atm}) = 611 \text{ J}$$

2. (4 points) In the following statement, fill in the blanks with the relevant thermodynamic terms, e.g.,  $\Delta G$ ,  $\Delta H$ ,  $\Delta S$ ,  $R$ , and/or combinations of them.

If the equilibrium constant ( $K$ ) for a reaction is measured at various temperatures ( $T$ ), a plot of  $\ln K$  on the y-axis vs  $1/T$  on the x-axis should be a straight line in which the slope =  $-\Delta H/R$  and the y-intercept =  $\Delta S/R$ .

3. (10 points) **SHOW ALL WORK.** Consider the following gas-phase reaction and the related thermodynamic data. Determine the equilibrium constant ( $K_p$ ) for this reaction at a temperature of 450 K.



Compound	$\Delta H^\circ_f$ (kJ/mole)	$S^\circ$ (J/mole·K)
$\text{CO}_2(\text{g})$	-393.5	213.8
$\text{CCl}_4(\text{g})$	-95.7	309.7
$\text{COCl}_2(\text{g})$	-219.1	283.5

$$\Delta H^\circ = 2(-219.1) - [(-393.5) + (-95.7)] = 51.0 \text{ kJ}$$

$$\Delta S^\circ = 2(283.5) - [213.8 + 309.7] = 43.5 \text{ J/K} = 0.0435 \text{ kJ/K}$$

Since  $\Delta H^\circ$  and  $\Delta S^\circ$  are relatively independent of temp, they can be used to estimate  $\Delta G$  and  $K$  at another temp.

$$\Delta G = \Delta H^\circ - T\Delta S^\circ = 51.0 \text{ kJ} - (450 \text{ K})(0.0435 \text{ kJ/K}) = 31.42 \text{ kJ}$$

$$\Delta G = -RT \ln K$$

$$\ln K = -\Delta G/RT = -(31.42 \text{ kJ}) / (8.314 \times 10^{-3} \text{ kJ/mole}\cdot\text{K})(450 \text{ K}) = -8.40$$

$$K = 2.25 \times 10^{-4}$$