

## 6.E: Putting the Second Law to Work (Exercises)

### Q6.1

Using Table T1, calculate the standard reaction Gibbs functions ( $\Delta G^\circ$ ) for the following reactions at 298 K.

- $CH_3CH_2OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$
- $C_6H_{12}O_6(s) + 6O_2 \rightarrow 6CO_2(g) + 6H_2O(l)$
- $2POCl_3(l) \rightarrow 2PCl_3(l) + O_2(g)$
- $2KBr(s) + Cl_2(g) \rightarrow 2KCl(s) + Br_2(l)$
- $SiH_4(g) + 2Cl(g) \rightarrow SiCl_4(l) + 2H_2(g)$

### Q6.2

Estimate  $\Delta G$  at 1000 K from its value at 298 K for the reaction



with  $\Delta G = -50.75 \text{ kJ at } 298 \text{ K}$

### Q6.3

The standard Gibbs function for formation ( $\Delta G_f^\circ$ ) of  $PbO_2(s)$  is  $-217.4 \text{ kJ/mol}$  at 298 K. Assuming  $O_2$  is an ideal gas, find the standard Helmholtz function for formation ( $\Delta A_f^\circ$  for  $PbO_2$  at 298K.

### Q6.4

Calculate the entropy change for 1.00 mol of an ideal monatomic gas ( $C_V = 3/2 R$ ) undergoing an expansion and simultaneous temperature increase from 10.0 L at 298 K to 205.0 L at 455 K.

### Q6.5

Consider a gas that obeys the equation of state

$$p = \frac{nRT}{V - nb} \quad (6.E.2)$$

- Find expressions for  $\alpha$  and  $\kappa_T$  for this gas.
- Evaluate the difference between  $C_p$  and  $C_V$  for the gas.

### Q6.6

Show that

$$\left( \frac{\partial C_p}{\partial p} \right)_T = 0 \quad (6.E.3)$$

for an ideal gas.

### Q6.7

Derive the thermodynamic equation of state

$$\left( \frac{\partial H}{\partial p} \right)_T = V(1 - T\alpha) \quad (6.E.4)$$

### Q6.8

Derive the thermodynamic equation of state

$$\left( \frac{\partial U}{\partial V} \right)_T = T \frac{\alpha}{\kappa_T} - p \quad (6.E.5)$$

### Q6.9

The “Joule Coefficient” is defined by

$$\mu_J = \left( \frac{\partial T}{\partial V} \right)_U \quad (6.E.6)$$

Show that

$$\mu_J = \frac{1}{C_V} \left( p - \frac{T\alpha}{\kappa_T} \right) \quad (6.E.7)$$

and evaluate the expression for an ideal gas.

### Q6.10

Derive expressions for the pressure derivatives

$$\left( \frac{\partial X}{\partial p} \right)_T \quad (6.E.8)$$

where  $X$  is  $U$ ,  $H$ ,  $A$ ,  $G$ , and  $S$  at constant temperature in terms of measurable properties. (The derivation of  $\left( \frac{\partial H}{\partial p} \right)_T$  was done in problem Q6.7).

Evaluate the expressions for

- $\left( \frac{\partial S}{\partial p} \right)_T$
- $\left( \frac{\partial H}{\partial p} \right)_T$
- $\left( \frac{\partial U}{\partial p} \right)_T$

for a van der Waals gas.

### Q6.11

Derive expressions for the volume derivatives

$$\left( \frac{\partial X}{\partial V} \right)_T \quad (6.E.9)$$

where  $X$  is  $U$ ,  $H$ ,  $A$ ,  $G$ , and  $S$  at constant temperature in terms of measurable properties. (The derivation of  $\left( \frac{\partial U}{\partial V} \right)_T$  was done in problem Q8.8.)

Evaluate the expressions for

- $\left( \frac{\partial X}{\partial V} \right)_T$
- $\left( \frac{\partial X}{\partial V} \right)_T$

for a van der Waals gas.

### Q6.12

Evaluate the difference between  $C_p$  and  $C_V$  for a gas that obeys the equation of state

$$p = \frac{nRT}{V - nb} \quad (6.E.10)$$

## Q6.13

The adiabatic compressibility ( $\kappa_S$ ) is defined by

$$\kappa_S = \frac{1}{V} \left( \frac{\partial V}{\partial p} \right)_S \quad (6.E.11)$$

Show that for an ideal gas,

$$\kappa_S = \frac{1}{p\gamma} \quad (6.E.12)$$

---

This page titled [6.E: Putting the Second Law to Work \(Exercises\)](#) is shared under a [CC BY-NC-SA 4.0](#) license and was authored, remixed, and/or curated by [Patrick Fleming](#).