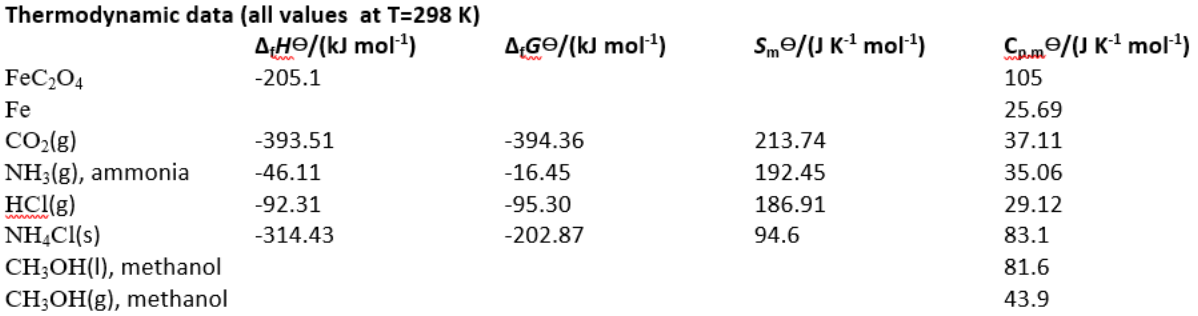
Thermodynamics tutorhour 6

In the resource section of Atkins the physical quantities are given with superscript $^{\ominus}$. These are the physical quantities, measured under standard conditions (p = 1 bar = $1.0 \cdot 10^5$ Pa, pure substances). Some examples are listed below:



Thermodynamic data (all values at T=298 K)

	$\Delta_f H^{\ominus}$/(kJ mol^{-1})	$\Delta_f G^{\ominus}$/(kJ mol^{-1})	$S_m^{\ominus}$/(J K^{-1} mol^{-1})	$C_{p,m}^{\ominus}$/(J K^{-1} mol^{-1})
FeC_2O_4	-205.1			105
Fe				25.69
CO_2(g)	-393.51	-394.36	213.74	37.11
NH_3(g), ammonia	-46.11	-16.45	192.45	35.06
HCl(g)	-92.31	-95.30	186.91	29.12
NH_4Cl(s)	-314.43	-202.87	94.6	83.1
CH_3OH(l), methanol				81.6
CH_3OH(g), methanol				43.9

Question 1

Iron(II) oxalate (FeC_2O_4) is a yellow solid.
When iron(II) oxalate is heated, it decomposes into iron and carbon dioxide.

a) Give the chemical equation for this decomposition.
b) Calculate $\Delta_r H$ for the decomposition of iron(II) oxalate at T=298 K, using the data from the resource section. You may use an enthalpy diagram.

In question 1b we calculated the enthalpy of the reaction at 25°C.
However, the reaction will not take place at 25°C. The decomposition will take place at a significant rate at a temperature of at least 423 K.
The $\Delta_f H^{\theta}$ at 423K is not listed in the resource section. The change of enthalpy at 423 K can be determined by using an alternative path.

c) Draw this alternative path in an enthalpy diagram.
d) Use the alternative path to calculate $\Delta_r H$ of the decomposition of iron(II) oxalate at T = 423 K.
e) Express the calculated enthalpy difference as a percentage of $\Delta_r H^{\theta}$ at 298 K.

Question 2

1.00 mole methanol is heated from 0°C to 100°C at a constant pressure equal to 1.0 bar.
The boiling point of methanol is 65°C. $\Delta_{vap} H$ = 38.0 kJ/mol.
Calculate ΔH and ΔS for this process. You may use the approximation that c_p is constant within these temperature ranges.

Additional material: Question 3

In question 1e we saw that the change of $\Delta_r H$ is less than 1% when the temperature increases by 125 K. The assumption that $\Delta_r H$ is temperature-independent is often a good approximation. Question 3 will show that this assumption is not valid for the Gibbs energy.
We consider the gaseous reaction of ammonia and hydrogen chloride, according to:

$$NH_3 + HCl \rightarrow NH_4Cl$$

a) Calculate $\Delta_r G^{\theta}$ for this process at 298K.
b) Calculate $\Delta_r G^{\theta}$ for this process at 423 K. Use sensible approximations.
c) Express the calculated Gibbs energy difference as a percentage of $\Delta_r G^{\theta}$ at 298 K.