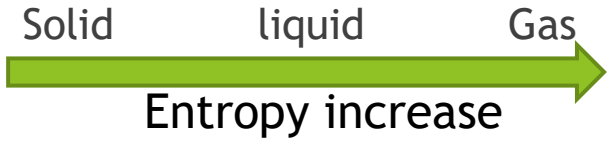
Revision of Chapter Two

Chapter Two

1. Which of the following species has the highest entropy (S°) at 25 °C?

a) $CH_3OH(l)$	b) $CO(g)$	c) $MgCO_3(s)$	d) $H_2O(l)$	e) Ni(s)



Chapter Two

1. Which of the following species has the highest entropy (S°) at 25 °C?

a) $CH_3OH(l)$	b) $CO(g)$	c) $MgCO_3(s)$	d) $H_2O(l)$	e) $Ni(s)$

2. Arrange the following compounds in order of increasing standard molar entropy at 25°C: $C_3H_8(g)$, $C_2H_4(g)$, $ZnS(s)$, and $H_2O(l)$

a) $ZnS(s) < H_2O(l) < C_3H_8(g) < C_2H_4(g)$
b) $C_2H_4(g) < H_2O(l) < C_3H_8(g) < ZnS(s)$
c) $ZnS(s) < C_3H_8(g) < C_2H_4(g) < H_2O(l)$
d) $C_3H_8(g) < C_2H_4(g) < H_2O(l) < ZnS(s)$
e) $ZnS(s) < H_2O(l) < C_2H_4(g) < C_3H_8(g)$

Molar mass ↑ Entropy ↑

$ZnS(s) < H_2O(l) < C_2H_4(g) < C_3H_8(g)$

C_3H_8 = 44 g/mol

C_2H_4 = 28 g/mol

Chapter Two

1. Which of the following species has the highest entropy (S°) at 25 °C?

a) $CH_3OH(l)$	b) $CO(g)$	c) $MgCO_3(s)$	d) $H_2O(l)$	e) $Ni(s)$

2. Arrange the following compounds in order of increasing standard molar entropy at 25°C: $C_3H_8(g)$, $C_2H_4(g)$, $ZnS(s)$, and $H_2O(l)$

a) $ZnS(s) < H_2O(l) < C_3H_8(g) < C_2H_4(g)$

b) $C_2H_4(g) < H_2O(l) < C_3H_8(g) < ZnS(s)$

c) $ZnS(s) < C_3H_8(g) < C_2H_4(g) < H_2O(l)$

d) $C_3H_8(g) < C_2H_4(g) < H_2O(l) < ZnS(s)$

e) $ZnS(s) < H_2O(l) < C_2H_4(g) < C_3H_8(g)$

3. Determine ΔS° for the reaction $SO_3(g) + H_2O(l) \rightarrow H_2SO_4(l)$ if you know : $S^\circ(SO_3)=256.2$ J/K.mol, $S^\circ(H_2O)=69.9$ J/K.mol, $S^\circ(H_2SO_4)=156.9$ J/K.mol,

a)169.2 J/K.mol	b)1343.2J/K.mol	c)-169.2J/K.mol	d)-29.4 J/K.mol	e) 29.4 J/K.mol

Chapter Two

3. Determine ΔS° for the reaction $SO_3(g) + H_2O(l) \rightarrow H_2SO_4(l)$ if you know : $S^\circ(SO_3)=256.2$ J/K.mol, $S^\circ(H_2O)=69.9$ J/K.mol, $S^\circ(H_2SO_4)=156.9$ J/K.mol,

a)169.2 J/K.mol	b)1343.2J/K.mol	c)-169.2J/K.mol	d)-29.4 J/K.mol	e) 29.4 J/K.mol

$\Delta S^\circ_{rxn} = \sum nS^0$ (products) - $\sum mH^0$ (reactants)

$\Delta S^\circ_{rxn} = (S^\circ(H_2SO_4)) - (S^\circ(SO_3) + S^\circ(H_2O))$

$\Delta S^\circ_{rxn} = (156.9) - (256.2+69.9)$

$= -169.2$ J/K.mol

Chapter Two

1. Which of the following species has the highest entropy (S°) at 25 °C?

a) $CH_3OH(l)$	b) $CO(g)$	c) $MgCO_3(s)$	d) $H_2O(l)$	e) Ni(s)

2. Arrange the following compounds in order of increasing standard molar entropy at 25°C: $C_3H_8(g)$, $C_2H_4(g)$, ZnS(s) , and $H_2O(l)$

a) $ZnS(s) < H_2O(l) < C_3H_8(g) < C_2H_4(g)$
b) $C_2H_4(g) < H_2O(l) < C_3H_8(g) < ZnS(s)$
c) $ZnS(s) < C_3H_8(g) < C_2H_4(g) < H_2O(l)$
d) $C_3H_8(g) < C_2H_4(g) < H_2O(l) < ZnS(s)$
e) $ZnS(s) < H_2O(l) < C_2H_4(g) < C_3H_8(g)$

3. Determine ΔS° for the reaction $SO_3(g) + H_2O(l) \rightarrow H_2SO_4(l)$ if you know : $S^\circ(SO_3)=256.2$ J/K.mol, $S^\circ(H_2O)=69.9$ J/K.mol, $S^\circ(H_2SO_4)=156.9$ J/K.mol,

a)169.2 J/K.mol	b)1343.2J/K.mol	c)-169.2J/K.mol	d)-29.4 J/K.mol	e) 29.4 J/K.mol

Chapter Two

4. A negative sign for ΔG indicate that, at constant T and P ,

a) The reaction is exothermic	b) The reaction is endothermic
c) The reaction is fast	d) The reaction is spontaneous

5. Ozone (O_3) in the atmosphere can react with nitric oxide (NO):
$O_3(g)+NO(g)\rightarrow NO_2(g)+O_2(g)$, Calculate the ΔG° for this reaction at 25°C.
(ΔH°= -199kJ/mol, ΔS°=-4.1 J/K.mol)

a)1020 kJ/mol	b)-1.22x10^3 kJ/mol	c)-1.42x10^3 kJ/mol	d)2x10^3 kJ/mol	e) -198 J/K.mol

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

$$= -199 - ((25+273)x \frac{(-4.1))}{1000}$$

$$= -198 \text{ kJ/mol}$$

Chapter Two

4. A negative sign for ΔG indicate that, at constant T and P ,

a) The reaction is exothermic	b) The reaction is endothermic
c) The reaction is fast	d) The reaction is spontaneous

5. Ozone (O_3) in the atmosphere can react with nitric oxide (NO):
$O_3(g)+NO(g)\rightarrow NO_2(g)+O_2(g)$, Calculate the ΔG° for this reaction at 25°C.
(ΔH°= -199kJ/mol, ΔS°=-4.1 J/K.mol)

a)1020 kJ/mol	b)-1.22×10^3 kJ/mol	c)-1.42×10^3 kJ/mol	d)2×10^3 kJ/mol	e) -198 J/K.mol

6. Sodium carbonate can be made by heating sodium bicarbonate:
$2NaHCO_3(s)\rightarrow Na_2CO_3(s)+CO_2(g)+H_2O(g)$, Given that ΔH°= 128.9 kJ/mol and ΔG°=33.1 kJ/mol at 25°C, above what minimum temperature will the reaction become spontanoius under standard state conditions?

a) 0.4 K	b) 3.9 K	c) 321 K	d) 401 K	e) 525K

Chapter Two

6. Sodium carbonate can be made by heating sodium bicarbonate: $2NaHCO_3(s) \rightarrow Na_2CO_3(s)+CO_2(g)+H_2O(g)$, Given that $\Delta H° = 128.9$ kJ/mol and $\Delta G° = 33.1$ kJ/mol at 25°C, above what minimum temperature will the reaction become spontanoius under standard state conditions?

a) 0.4 K	b) 3.9 K	c) 321 K	d) 401 K	e) 525K

$\Delta H = T\Delta S$

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

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

$$\Delta S° = \frac{\Delta H° - \Delta G°}{T}$$

$$= \frac{128.9 - 33.1}{25 + 273} = 0.321 \text{ kJ/K.mol}$$

$\Delta H = T\Delta S$

$$T = \frac{\Delta H}{\Delta S} = \frac{128.9}{0.321}$$

$$= 401\ K$$

Chapter Two

4. A negative sign for ΔG indicate that, at constant T and P ,

a) The reaction is exothermic	b) The reaction is endothermic
c) The reaction is fast	d) The reaction is spontaneous

5. Ozone (O_3) in the atmosphere can react with nitric oxide (NO):
$O_3(g)+NO(g)\rightarrow NO_2(g)+O_2(g)$, Calculate the ΔG° for this reaction at 25°C.
(ΔH°= -199kJ/mol, ΔS°=-4.1 J/K.mol)

a)1020 kJ/mol	b)-1.22×10^3 kJ/mol	c)-1.42×10^3 kJ/mol	d)2×10^3 kJ/mol	e) -198 J/K.mol

6. Sodium carbonate can be made by heating sodium bicarbonate:
$2NaHCO_3(s)\rightarrow Na_2CO_3(s)+CO_2(g)+H_2O(g)$, Given that ΔH°= 128.9 kJ/mol and ΔG°=33.1 kJ/mol at 25°C, above what minimum temperature will the reaction become spontanoius under standard state conditions?

a) 0.4 K	b) 3.9 K	c) 321 K	d) 401 K	e) 525K

Chapter Two

7. For the reaction $H_2(g)+S(s)\rightarrow H_2S(g)$, $\Delta H°$=-20.2 kJ/mol and $\Delta S°$=+43.1 J/K.mol. Which of the following statement is true?

a) The reaction is only spontaneous at low temperatures.

b) The reaction is spontaneous at all temperatures.

c) $\Delta G°$ become less favorable as temperature increases.

d) The reaction is spontaneous only at high temperatures

e) The reaction is at equilibrium at 25°C under standard conditions.

TABLE 18.3 Factors Affecting the Sign of ΔG in the Relationship $\Delta G = \Delta H - T\Delta S$

ΔH	ΔS	ΔG	Example
+	+	Reaction proceeds spontaneously at high temperatures. At low temperatures, reaction is spontaneous in the reverse direction.	$2HgO(s) \longrightarrow 2Hg(l) + O_2(g)$
+	−	ΔG is always positive. Reaction is spontaneous in the reverse direction at all temperatures.	$3O_2(g) \longrightarrow 2O_3(g)$
−	+	ΔG is always negative. Reaction proceeds spontaneously at all temperatures.	$2H_2O_2(aq) \longrightarrow 2H_2O(l) + O_2(g)$
−	−	Reaction proceeds spontaneously at low temperatures. At high temperatures, the reverse reaction becomes spontaneous.	$NH_3(g) + HCl(g) \longrightarrow NH_4Cl(s)$

Chapter Two

7. For the reaction $H_2(g)+S(s)\rightarrow H_2S(g)$, $\Delta H°=-20.2$ kJ/mol and $\Delta S°=+43.1$ J/K.mol. Which of the following statement is true?

a) The reaction is only spontaneous at low temperatures.

b) The reaction is spontaneous at all temperatures.

c) ΔG° become less favorable as temperature increases.

d) The reaction is spontaneous only at high temperatures

e) The reaction is at equilibrium at 25°C under standard conditions.

8. Determine the equilibrium constant Kp at 25°C for the reaction $N_2(g)+3H_2(g)\leftrightarrow 2NH_3(g)$ ($\Delta G_f°(NH_3(g))=-16.6$ kJ/mol)

a) $1.52x10^{-6}$	b) $6.60x10^{5}$	c) $8.28x10^{-2}$	d) 2.60	e) 13.4

$\Delta G^\circ = - RT \ln Kp$

$\Delta G^0_{rxn} = \Sigma\ n\Delta G^0_f(\text{products}) - \Sigma m\Delta G^0_f(\text{reactants})$

$\Delta G^\circ_{rxn} = (2x\Delta G°_f NH_3) - ((\Delta G°_f N_2)+(3x\Delta G°_f H_2))$

$=(2x\ -16.6)-(0+(3x0)) = -33.2$ kJ/mol

$\Delta G^\circ = - RT \ln Kp$

$$\ln K_p = \frac{\Delta G°}{-RT} = \frac{-33.2}{\frac{-8.314x298}{1000}} = 13.4$$

$$K_p = e^{13.4} = 6.6x10^5$$

Chapter Two

7. For the reaction $H_2(g)+S(s)\rightarrow H_2S(g)$, $\Delta H°=-20.2$ kJ/mol and $\Delta S°=+43.1$ J/K.mol. Which of the following statement is true?

a) The reaction is only spontaneous at low temperatures.

b) The reaction is spontaneous at all temperatures.

c) $\Delta G°$ become less favorable as temperature increases.

d) The reaction is spontaneous only at high temperatures

e) The reaction is at equilibrium at 25°C under standard conditions.

8. Determine the equilibrium constant Kp at 25°C for the reaction $N_2(g)+3H_2(g)\leftrightarrow 2NH_3(g)$ ($\Delta G_f°(NH_3(g))=-16.6$ kJ/mol)

a) 1.52×10^{-6}	b) 6.60×10^{5}	c) 8.28×10^{-2}	d) 2.60	e) 13.4

Chapter Two

9. For the reaction 2C (graphite)+ $H_2(g) \rightarrow C_2H_2(g)$, $\Delta G° = 209.2$ kJ/mol at 25°C. if $P(H_2) = 100$atm and $P(C_2H_2) = 0.10$ atm, calculate ΔG for this reaction?

a) 207.8kJ/mol	b) 226.3 kJ/mol	c) 192.1 kJ/mol	d) 17.3 kJ/mol	e)-16.9 kJ/mol

$$\Delta G = \Delta G° + RT \ln Q$$

$$Q = \frac{P_{C_2H_2}}{P_{H_2}}$$

$$\Delta G = 209.2 + \frac{8.314x298}{1000} \ln \frac{0.1}{100}$$

$$\Delta G = 209.2 - 17.11$$

$$= 192.1 \text{ kJ/mol}$$

Chapter Two

9. For the reaction 2C (graphite)+ $H_2(g) \rightarrow C_2H_2(g)$, $\Delta G° = 209.2$ kJ/mol at 25°C. if $P(H_2) = 100$atm and $P(C_2H_2) = 0.10$ atm, calculate ΔG for this reaction?

a) 207.8kJ/mol	b) 226.3 kJ/mol	c) 192.1 kJ/mol	d) 17.3 kJ/mol	e)-16.9 kJ/mol