LECTURE 17

1. The health risks of accidental exposure to a toxic heavy metal, such as lead, mercury, or cadmium, may be reduced through treatment with a chelating agent, which binds to the metal and forms a complex that can be eliminated from the body. Methylamine (CH_3NH_2) and ethyldiamine ($NH_2CH_2CH_2NH_2$) chelate cadmium as shown in the following reactions.

(1) $Cd^{2+} + 2CH_3NH_2 \rightarrow Cd(CH_3NH_2)_2^{2+}$ ΔH = -7.03 kcal/mol, ΔS = -1.58 cal/(molK)

(2) $Cd^{2+} + NH_2CH_2CH_2NH_2 \rightarrow Cd(NH_2CH_2CH_2NH_2)^{2+}$ ΔH = -7.02 kcal/mol, ΔS= 3.15 cal/(molK)

(a) Based on strictly thermodynamic analysis, and assuming a body temperature of 37°C and that ΔH and ΔS are independent of temperature, which would you administer to a patient exposed to cadmium? Explain.

(b)Over what temperature ranges are reaction (1) and reaction (2) spontaneous?

(a) Ethyldiamine ($NH_2CH_2CH_2NH_2$).

(b) Reaction (1) is spontaneous up to 4450 K; Reaction (2) is spontaneous at all temperatures.

2. Consider the following compounds: (a) Al_2O_3(s); (b) H_2O_2(l); (c) NO(g). Using the table of thermodynamic data below:

(i) Determine which of the above compounds are **stable with respect to decomposition** into their elements under standard conditions at room temperature. Explain your answer.

(ii) Determine which of the above compounds become **more stable** and which become **less stable** with respect to their elements as the temperature is raised. Explain your answer.

(i)

(a) Al_2O_3 (s): **thermodynamically stable**

(b) H_2O_2 (l): **thermodynamically stable**

(b) NO (*g*): **thermodynamically unstable**

(ii)

(a) Al_2O_3 is **less stable** at higher temperatures.

(b) H_2O_2 is **less stable** at higher temperatures.

(c) NO is **more stable** at higher temperatures.

LECTURE 17

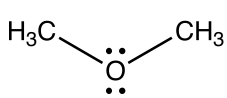
Selected thermodynamic data at 25°C from Appendix 2A (Adapted from Atkins and Jones)

Substance	Mass (g/mol)	$\Delta H_f°$ (kJ/mol)	$\Delta G_f°$ (kJ/mol)	S° (J/Kmol)
Al(s)	26.98	0	0	28.33
Al_2O_3(s)	101.96	-1676	-1582	50.92
$AlCl_3$(s)	133.33	-704.2	-628.8	110.67
Cl_2(g)	70.9	0	0	223.07
Cl(g)	35.45	121.7	105.7	165.2
HCl(g)	36.46	-92.31	-95.3	29.12
H_2(g)	2.0158	0	0	130.7
H_2O_2(*l*)	34.02	-187.8	-120.35	109.6
N_2(g)	28.02	0	0	191.61
NO(g)	30.01	90.25	86.55	210.76
O_2(g)	32	0	0	205.14
O_3(g)	48	142.7	163.2	238.93

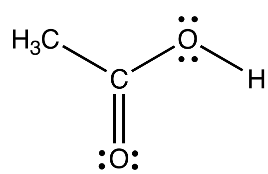
3. For (a) CH_3OCH_3; (b) CH_3COOH; (c) CH_3CHO; (d) CH_3CH_2OH.
   (i) Which of the above can act as a hydrogen bond donor?
   (ii) Which of the above can act as a hydrogen bond acceptor?
   Hint: draw Lewis structures before answering this question.

   Let's consider the structures to determine which of the molecules have H atoms bonded to an O, N, or F (only those molecules have a sufficient partial positive charge on the hydrogen can act as a H-bond donor.)

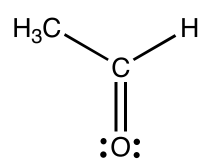
(a)



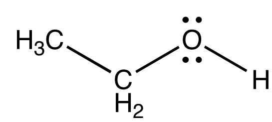
(b)



(c)



(d)



(i) Only **CH_3COOH (b) and CH_3CH_2OH (d)** can act as a hydrogen bond donors.

(ii) All four can act as a hydrogen bond acceptor.

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