

Project Advance Chemistry 116 Sample Questions  
on Material in *General Chemistry*, Brown, LeMay, and Bursten

Chapter 19. Chemical Thermodynamics  
Spring 1996

1. Which reaction below should have  $\Delta S^\circ > 0$ ?

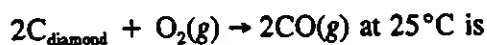
- (a)  $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{g})$
- (b)  $2\text{NO}_2(\text{g}) \rightarrow \text{N}_2\text{O}_4(\text{g})$
- (c)  $\text{H}^+(\text{aq}) + \text{F}^-(\text{aq}) \rightarrow \text{HF}(\text{aq})$
- (d)  $\text{BaF}_2(\text{s}) \rightarrow \text{Ba}^{2+}(\text{aq}) + 2\text{F}^-(\text{aq})$
- (e)  $2\text{Hg}(\text{l}) + \text{O}_2(\text{g}) \rightarrow 2\text{HgO}(\text{s})$

2. The table shown below contains entropy values for four substances at  $25^\circ\text{C}$ . All of the values are correct except one. Which one is incorrect?

- (a) 203
- (b) 115
- (c) 158
- (d) 117
- (e) none of these.

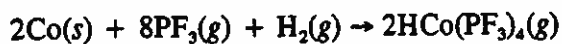
Substance	$S^\circ(\text{J/mol}\cdot\text{K})$
$\text{F}_2(\text{g})$	203
$\text{Cl}_2(\text{g})$	115
$\text{Br}_2(\text{l})$	158
$\text{I}_2(\text{s})$	117

3. Some standard entropies (at  $25^\circ\text{C}$  in  $\text{J/mol}\cdot\text{K}$ ) are: diamond, C, 2.43; oxygen,  $\text{O}_2(\text{g})$ , 205.0; carbon monoxide,  $\text{CO}(\text{g})$  197.9. The change in entropy,  $\Delta S^\circ$ , for the reaction:



- (a) -185.9
- (b) +185.9
- (c) -9.5
- (d) +9.5
- (e) -195.7

4. Using  $\Delta G^\circ_f$  values to calculate  $\Delta G^\circ$  for the reaction:



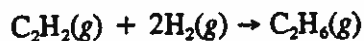
which species *has/have*  $\Delta G^\circ_f = 0$ ?

- (a)  $\text{Co}(\text{s})$
- (b)  $\text{PF}_3(\text{g})$
- (c)  $\text{H}_2(\text{g})$
- (d)  $\text{HCo}(\text{PF}_3)_4(\text{g})$
- (e) both  $\text{Co}(\text{s})$  and  $\text{H}_2(\text{g})$

5. Dissolving ammonium chloride in water lowers the temperature of the system. For this dissolving process
- (a)  $\Delta H$  is negative and  $\Delta S$  is negative.
  - (b)  $\Delta H$  is positive and  $\Delta S$  is positive.
  - (c)  $\Delta H$  is negative and  $\Delta S$  is positive.
  - (d)  $\Delta H$  is positive and  $\Delta S$  is negative.
6. Which one of the following processes has a *negative* standard free energy change at 25°C?
- (a)  $\text{CO}_2(g) + 2\text{H}_2\text{O}(l) \rightarrow \text{CH}_4(g) + 2\text{O}_2(g)$
  - (b)  $2\text{Na}(s) + 2\text{H}_2\text{O}(l) \rightarrow 2\text{NaOH}(aq) + \text{H}_2(g)$
  - (c)  $2\text{H}_2\text{O}(l) \rightarrow 2\text{H}_2(g) + \text{O}_2(g)$
  - (d)  $2\text{KCl}(s) \rightarrow 2\text{K}(s) + \text{Cl}_2(g)$
  - (e) none of these.
7. Consider the following thermodynamic data. All values are tabulated for 25°C.

Substance	$\Delta G_f^\circ$ (kJ/mol)	$S^\circ$ (J/mol·K)
$\text{C}_2\text{H}_2(g)$	209	201
$\text{C}_2\text{H}_4(g)$	68	219
$\text{C}_2\text{H}_6(g)$	-33	230
$\text{H}_2(g)$	0	131
$\text{H}_2\text{O}(g)$	-229	189
$\text{C}_2\text{H}_5\text{OH}(l)$	-175	161

What is the value of  $\Delta H^\circ$  (in kJ) for the following reaction which takes place at 25°C.

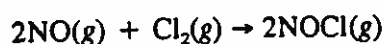


- (a) -173
- (b) 236
- (c) -311
- (d) -248
- (e) none of these.

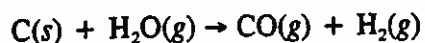
8. Consider the following table of thermodynamic data.

Substance	$\Delta G^\circ_f$ (kJ/mol)	$S^\circ$ (J/mol·K)
NO(g)	86.7	211
NO <sub>2</sub> (g)	51.8	240
NOCl(g)	66.3	264
N <sub>2</sub> O(g)	103.6	220

The value of  $\Delta S^\circ$  for the following reaction is -117 J/K at 25°C. What is the entropy of Cl<sub>2</sub>(g) at 25°C?



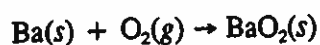
- (a) 106  
(b) 11  
(c) 223  
(d) -223  
(e) none of these.
9. For the reaction shown below  $\Delta S^\circ = 135 \text{ J}$  and  $\Delta G^\circ = 91.2 \text{ kJ}$  at 25°C.



What is the value of  $\Delta H^\circ$  (in kJ) for this reaction at 25°C?

- (a) 40.3 kJ  
(b) 131.4 kJ  
(c) 226 kJ  
(d) 91.3 kJ  
(e) none of these.
10. Assuming  $\Delta H$  and  $\Delta S$  do not vary with temperature, a reaction that is not spontaneous at low temperatures can become spontaneous at high temperatures if  $\Delta H$  is \_\_\_\_\_ and  $\Delta S$  is \_\_\_\_\_.
- (a) positive, positive  
(b) negative, negative  
(c) positive, negative  
(d) negative, positive  
(e) not enough information to determine spontaneity.

11. The entropy of vaporization,  $\Delta S^\circ_{\text{vap}}$ , for benzene is  $96.4 \text{ J/K} \cdot \text{mol}$ . The enthalpy of vaporization,  $\Delta H^\circ_{\text{vap}}$ , is  $33.9 \text{ kJ/mol}$ . What is the normal boiling point (in  $^\circ\text{C}$ ) for benzene?
- (a) 2.8  
(b) 0.35  
(c) 100  
(d) 79  
(e) none of these.
12. For the reaction  $\text{A}(l) + 2\text{D}(g) \rightarrow 3\text{X}(g) + \text{Z}(s)$   $\Delta G^\circ = +512 \text{ kJ}$ . This means that the equilibrium mixture
- (a) will consist almost exclusively of A and D.  
(b) will consist almost exclusively of A and Z.  
(c) will consist almost exclusively of X and Z.  
(d) will consist of significant amounts of A, D, X, and Z.  
(e) has a composition predictable only if one knows T and  $\Delta H^\circ$ .
13. Which one of the following statements is true about the equilibrium constant,  $K$ , for a reaction if  $\Delta G^\circ$  for the reaction is less than zero?
- (a)  $K = 0$   
(b)  $K = 1$   
(c)  $K > 1$   
(d)  $K < 1$   
(e) not able to determine.
14. The value of the equilibrium constant for a particular reaction is 0.48 at  $25^\circ\text{C}$ . What is the value of  $\Delta G^\circ$  (in kJ) for the reaction at  $25^\circ\text{C}$ ? ( $R = 8.314 \text{ J/K} \cdot \text{mol}$ )
- (a) 1.8  
(b) -4.2  
(c)  $1.5 \times 10^2$   
(d) 4.2  
(e) none of these.
15. When the reaction below was run in a bomb calorimeter at  $25^\circ\text{C}$  it was exothermic by 627.0 kilojoules per mole of  $\text{BaO}_2$  formed.



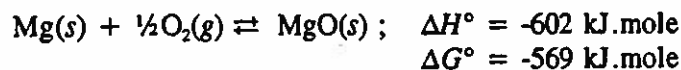
What is  $\Delta H^\circ$  (in kJ) for the reaction?

- (a) +624.5  
(b) +1883  
(c) -629.5  
(d) -624.5  
(e) -627.0

16. Which of the following reactions shows the least change in entropy?

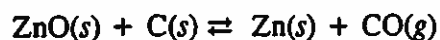
- (a)  $C_6H_{10}(g) \rightarrow C_6H_6(g) + 2H_2(g)$
- (b)  $3Fe_2O_3(s) \rightarrow 2Fe_3O_4(s) + \frac{1}{2}O_2(g)$
- (c)  $C_6H_6(g) + 3H_2(g) \rightarrow C_6H_{12}(g)$
- (d)  $Ag_2O_2 + H_2(g) \rightarrow 2Ag(s) + H_2O(g)$
- (e)  $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

17. In the reaction:



which of the following is true?

- (a) The large enthalpy insures that this reaction will spontaneously occur at any temperature.
  - (b) The reaction is spontaneous because it is accompanied by an increase in entropy.
  - (c) The negative free energy change means that the equilibrium must be displaced to the left (toward the reactants).
  - (d) Because of the decrease in entropy both the free energy and enthalpy changes are negative.
  - (e) The entropy factor is less significant than the enthalpy in determining the direction of this reaction.
18. Calculate  $K_p$  at 298 K for the following reaction, given the standard free energies of formation listed for each compound.



- (a)  $9.66 \times 10^{-74}$
- (b)  $1.63 \times 10^3$
- (c) 0.930
- (d)  $1.98 \times 10^{32}$
- (e)  $6.14 \times 10^{-4}$

Compound	$\Delta G_f^\circ$ kJ/mole
ZnO(s)	-318.2
CO(g)	-137.3

