CHEMISTRY 102  
EXAM 1  FORM C  
SECTIONS 514-524  
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PART 1

1&2. Which one of the following thermodynamic quantities is NOT a state function?

(a) Gibbs free energy  (b) pressure  (c) enthalpy  
(d) heat  (e) internal energy

3&4. Which response includes ONLY the following processes that are accompanied by an increase in entropy?

1. I₂(s) → I₂(g)  2. 2I(g) → I₂(g)  
3. 2NH₃(g) → N₂(g) + 3H₂(g)  4. Mg²⁺(aq) + 2OH⁻(aq) → Mg(OH)₂(s)

(a) 1,3  (b) 1,2  (c) 3,4  (d) 3  (e) another combination

5&6. Which of the following statements is FALSE?

(a) ∆S alone does not determine the spontaneity of a reaction.  
(b) ∆G is a state function.  
(c) Some spontaneous processes are endothermic.  
(d) If the internal energy of a system is increasing, (q + w) must also be increasing.  
(e) Exothermic processes are those with ∆H > 0.
7&8. All of the following would be expected to have enthalpy of formation values of zero EXCEPT:

(a) Hg(\textit{l})   
(b) Sr(s)   
(c) C\textit{graphite}(s)   
(d) O\textit{2}(g)   
(e) CO\textit{2}(g)

9&10. Which one of the following statements is FALSE?

(a) The work done in the process occurring at constant pressure is zero when $\Delta n_{\text{gases}}$ is zero.
(b) The bomb calorimeter measures $\Delta H$ directly.
(c) The change in internal energy, $\Delta E$, for a process is equal to the amount of heat absorbed at constant volume, $q_v$.
(d) The change in enthalpy, $\Delta H$, for a process is equal to the amount of heat absorbed at constant pressure, $q_p$.
(e) If $q_p$ for a process is negative, the process must be exothermic.

11&12. The correct name for (CH\textit{3})\textit{2}NH is:

(a) bimethynitrate   
(b) ammonia   
(c) dimethylamine   
(d) methylamine   
(e) trimethylamine

13&14. For the following reaction at 25°C, $\Delta H^\circ = -26.88$ kJ and $\Delta S^\circ = +11.2$ J/K. Calculate $\Delta G^\circ$ for the reaction in kilojoules.

$I_2(g) + Cl_2(g) \rightarrow 2 ICl(g)$

(a) -30.2 kJ   
(b) -50.6 kJ   
(c) -325 kJ   
(d) +50.6 kJ   
(e) -3375 kJ
15&16. When 2.00 g of aluminum is burned in excess $O_2$ to form $Al_2O_3$ at constant pressure, 61.9 kJ of heat are evolved. What is the heat of formation of $Al_2O_3$?

(a) -31.0 kJ/mol  
(b) -124 kJ/mol  
(c) -836 kJ/mol  
(d) -1670 kJ/mol  
(e) -6320 kJ/mol

17&18. At the boiling point of carbon disulfide, $CS_2$, $\Delta H = 26.9$ kJ/mol and $\Delta S = 84.5$ J/mol$\cdot$K. Determine the normal boiling temperature in $^\circ$C for $CS_2$.

(a) -142 $^\circ$C  
(b) 0.35 $^\circ$C  
(c) 45 $^\circ$C  
(d) 130 $^\circ$C  
(e) 210 $^\circ$C

19&20. A system suffers an increase in internal energy of 90 J and at the same time does 40 J of work. What is the heat change of the system?

(a) +50 J  
(b) +130 J  
(c) -130 J  
(d) -50 J  
(e) 0 J
21&22. Consider the reaction below and choose the correct statement:

\[ 2 \text{H}_2\text{O}(l) + \text{O}_2(g) \rightarrow 2 \text{H}_2\text{O}_2(l) \quad \Delta H^\circ = +196 \text{ kJ} \]
\[ \Delta S^\circ = -126 \text{ J/K} \]

(a) The reaction becomes spontaneous as the temperature rises.
(b) The reaction becomes spontaneous as the temperature decreases.
(c) The reaction is spontaneous at all temperatures.
(d) The reaction is nonspontaneous at all temperatures.
(e) Nothing can be said about the spontaneity of a reaction from the values of \( \Delta H^\circ \) and \( \Delta S^\circ \) only.

23&24. Calculate the amount of work done for the conversion of 1.00 mole of Ni to Ni(CO)_4 in the reaction below at 75°C. Assume that the gases are ideal.

\[ \text{Ni (s) } + \text{4 CO (g) } \rightarrow \text{Ni(CO)}_4 (\text{g}) \]

(a) +1.80 x 10^3 J  \hspace{1cm} (b) +8.68 x 10^3 J  \hspace{1cm} (c) -1.80 x 10^3 J
(d) -8.68 x 10^3 J  \hspace{1cm} (e) -494 J
(5 pts) **25.** The following reaction is one that occurs in a blast furnace when iron is extracted from its ores:

$$
\text{Fe}_2\text{O}_3(s) + 3\text{CO}(g) \rightarrow 2\text{Fe}(s) + 3\text{CO}_2(g)
$$

Estimate the enthalpy change, $\Delta H^\circ$, for this reaction (in kJ/mol rxn) using the following equations with their enthalpies. Show all your work.

<table>
<thead>
<tr>
<th>Reaction</th>
<th>$\Delta H^\circ$ (kJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$3\text{Fe}_2\text{O}_3(s) + \text{CO(g)} \rightarrow 2\text{Fe}_3\text{O}_4(s) + \text{CO}_2(g)$</td>
<td>$-46.4$</td>
</tr>
<tr>
<td>$\text{FeO}(s) + \text{CO(g)} \rightarrow \text{Fe}(s) + \text{CO}_2(g)$</td>
<td>$+9.0$</td>
</tr>
<tr>
<td>$\text{Fe}_3\text{O}_4(s) + \text{CO(g)} \rightarrow 3\text{FeO(s)} + \text{CO}_2(g)$</td>
<td>$-41.0$</td>
</tr>
</tbody>
</table>
26. A 2.56 g sample of sulfur was completely burned in a bomb calorimeter. The temperature of the water increased from 21.25°C to 26.72°C. The bomb has a heat capacity of 923 J/°C and the calorimeter contains 815 g of water. The specific heat of liquid water is 4.18 J/g°C.

(a) Calculate the heat released (in kJ) for the reaction: \( S_8(s) + 8O_2(g) \rightarrow 8 SO_2(g) \)

(b) Determine \( \Delta E \) for the reaction (in kJ/mol \( S_8 \)).

(c) What is the \( \Delta H \) for the reaction (in kJ/mol \( S_8 \))? Give an explanation.
27. Consider the following reaction and standard molar enthalpy of formation data:

$$\begin{align*}
\text{C}_2\text{H}_6 \text{ (g)} &+ \text{O}_2 \text{ (g)} \rightarrow \text{CO}_2 \text{ (g)} + \text{H}_2\text{O (l)} \\
\Delta H^\circ_{298} (\text{kJ/mol}) &\quad -84.86 \quad 0 \quad -393.5 \quad -285.8
\end{align*}$$

(3 pts) (a) What is the name of C\textsubscript{2}H\textsubscript{6}? ________________________

(3 pts) (b) Balance the equation.

(4 pts) (c) What is the enthalpy change per mole of C\textsubscript{2}H\textsubscript{6} in the BALANCED combustion reaction at 298 K and 1 atm pressure? Show work.

(5 pts) (d) How much of C\textsubscript{2}H\textsubscript{6} (in grams) is combusted in the above reaction if 465 kJ of heat is released? (If you couldn't get an answer for (c), use $\Delta H_{\text{rxn}} = -2000 \text{ kJ/mol C}_2\text{H}_6$).
28. Write down the reaction whose $\Delta H^\circ$ of reaction is equal to the $\Delta H^\circ$ of formation of the compound.

(2 pts) (a) Fe(CO)$_5$(l)

(2 pts) (b) Br$_2$(g)

29. Consider the following process: $\text{H}_2\text{O}(l) \rightarrow \text{H}_2\text{O}(g)$. For water, $T_{\text{boiling}} = 100^\circ\text{C}$

Discuss the signs of $\Delta H^\circ$, $\Delta S^\circ$, and $\Delta G^\circ$ for this process. How does temperature come into play, if at all? Use your new-found chemistry common sense. Explain your reasoning in a short paragraph.