1. A particular chemical reaction has $\Delta H^\circ = +5 \text{ kJ mol}^{-1}$ and $\Delta S^\circ = +25 \text{ J K}^{-1} \text{ mol}^{-1}$. Assuming that these values do not change with temperature, in what temperature range is $\Delta G^\circ$ negative?
   a) at all temperatures
   b) at no temperature
   c) $T > 200 \text{ K}$
   d) $T < 200 \text{ K}$
   e) $T < -200 \text{ K}$

2. An ideal gas receives 245 J of heat and expands by 1.30 L against an external pressure of 60.0 kPa. What is the change in internal energy of the system?
   a) +167 J
   b) +323 J
   c) −323 J
   d) −167 J
   e) 0 kJ as there are no forces between ideal gas molecules

3. Use the data below to calculate $\Delta S^\circ_{\text{total}}$ for the deposition of iodine at 298 K.

<table>
<thead>
<tr>
<th></th>
<th>$\Delta H^\circ$ (kJ mol$^{-1}$)</th>
<th>$S^\circ$ (J K$^{-1}$ mol$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I$_2$(s)</td>
<td>0.00</td>
<td>116</td>
</tr>
<tr>
<td>I$_2$(g)</td>
<td>62</td>
<td>261</td>
</tr>
</tbody>
</table>

   a) −353. J K$^{-1}$ mol$^{-1}$
   b) −63.1 J K$^{-1}$ mol$^{-1}$
   c) +63.1 J K$^{-1}$ mol$^{-1}$
   d) +353 J K$^{-1}$ mol$^{-1}$
   e) +377 J K$^{-1}$ mol$^{-1}$

4. In which one of the following processes does the entropy of the system decrease?
   Assume constant temperature and pressure unless specifically indicated otherwise.
   a) CO$_2$(s) $\rightarrow$ CO$_2$(g)
   b) 1 mol H$_2$(g) at 10 atm $\rightarrow$ 1 mol H$_2$(g) at 1 atm
   c) O$_2$(g) + 2CO(g) $\rightarrow$ 2CO$_2$(g)
   d) C$_2$H$_5$OH(l) at 20 °C $\rightarrow$ C$_2$H$_5$OH(l) at 40 °C
   e) C$_8$H$_{14}$(l) $\rightarrow$ C$_4$H$_6$(g) + C$_4$H$_8$(g)
Questions 5 and 6 refer to the following reaction:  \( 2\text{NO}_2(g) \rightleftharpoons \text{N}_2\text{O}_4(g) \)

\( K = 7.1 \) at 25 \(^\circ\text{C}\) and \( K = 5.5 \) at 70 \(^\circ\text{C}\).

5. Which one of the following statements is true?
   a) \( \Delta H^\circ < 0 \) and lowering the temperature favours products.
   b) \( \Delta H^\circ > 0 \) and raising the temperature favours products.
   c) \( \Delta H^\circ > 0 \) and raising the temperature favours reactants.
   d) \( \Delta H^\circ < 0 \) and lowering the temperature favours reactants.
   e) There is insufficient information to work out the sign of \( \Delta H^\circ \).

6. What is the value of \( K \) for the following reaction at 25 \(^\circ\text{C}\)?
   a) -7.1
   b) -3.6
   c) 0.14
   d) 0.37
   e) 0.020

7. Given the following thermochemical data, what is the enthalpy of formation \( \Delta f H_{298} \) for \( \text{C}_2\text{H}_5\text{OH}(l) \) at 298 K and 100 kPa?
   a) +277 kJ mol\(^{-1}\)
   b) -277 kJ mol\(^{-1}\)
   c) -688 kJ mol\(^{-1}\)
   d) +688 kJ mol\(^{-1}\)
   e) +542 kJ mol\(^{-1}\)

8. What is the oxidation number of C in \( \text{NaHCO}_3 \)?
   a) +IV
   b) +II
   c) 0
   d) –II
   e) –IV

9. Samples of A (2.0 mol) and B (3.0 mol) are placed in a 10.0 L container and the following reaction takes place:  \( 2\text{A}(g) \rightleftharpoons 3\text{B}(g) \)

At equilibrium, the concentration of A is 0.14 M. What is the value of \( K \)?
   a) 3.0
   b) 0.33
   c) 2.4
   d) 0.42
   e) 6.8

10. For the reaction in question 9, what is the effect of increasing the volume of the container at constant temperature?
    a) \( K \) increases because all the reactant and product concentrations increase.
    b) The reaction proceeds towards the reactants.
    c) No change because the reaction does not alter the total number of moles present.
    d) The reaction proceeds towards the products.
    e) There is insufficient information provided to make a prediction.

Correct answers: 1C, 2A, 3C, 4C, 5A, 6D, 7B, 8A, 9A, 10D
1. A particular chemical reaction has \( \Delta H^o = -5 \text{ kJ mol}^{-1} \) and \( \Delta S^o = +25 \text{ J K}^{-1} \text{ mol}^{-1} \). Assuming that these values do not change with temperature, in what temperature range is \( \Delta G^o \) negative?

a) at all temperatures  
b) at no temperature  
c) \( T > 200 \text{ K} \)  
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e) \( T < -200 \text{ K} \)

2. An ideal gas receives 245 J of heat and contracts by 1.30 L against an external pressure of 60.0 kPa. What is the change in internal energy of the system?

a) +167 J  
b) +323 J  
c) −323 J  
d) −167 J  
e) 0 kJ as there are no forces between ideal gas molecules

3. Use the data below to calculate \( \Delta S^o_{\text{total}} \) for the sublimation of iodine at 298 K.

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a) −353. J K\(^{-1}\) mol\(^{-1}\)  
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c) +63.1 J K\(^{-1}\) mol\(^{-1}\)  
d) +353 J K\(^{-1}\) mol\(^{-1}\)  
e) +377 J K\(^{-1}\) mol\(^{-1}\)

4. In which one of the following processes does the entropy of the system increase? Assume constant temperature and pressure unless specifically indicated otherwise.

a) CO\(_2\)(g) \( \rightarrow \) CO\(_2\)(s)  
b) 1 mol H\(_2\)(g) at 1 atm \( \rightarrow \) 1 mol H\(_2\)(g) at 10 atm  
c) 2CO\(_2\)(g) \( \rightarrow \) O\(_2\)(g) \( + \) 2CO(g)  
d) C\(_2\)H\(_5\)OH(l) at 40 °C \( \rightarrow \) C\(_2\)H\(_5\)OH(l) at 20 °C  
e) C\(_4\)H\(_6\)(g) \( + \) C\(_4\)H\(_8\)(g) \( \rightarrow \) C\(_8\)H\(_{14}\)(l)
Questions 5 and 6 refer to the following reaction: \[ \text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g}) \]

\[ K = 0.14 \text{ at } 25 \, ^\circ \text{C} \text{ and } K = 0.18 \text{ at } 70 \, ^\circ \text{C}. \]

5. Which one of the following statements is true?
   a) \( \Delta H^\circ > 0 \) and raising the temperature favours products.
   b) \( \Delta H^\circ < 0 \) and lowering the temperature favours products.
   c) \( \Delta H^\circ > 0 \) and raising the temperature favours reactants.
   d) \( \Delta H^\circ < 0 \) and lowering the temperature favours reactants.
   e) There is insufficient information to work out the sign of \( \Delta H^\circ \).

6. What is the value of \( K \) for the following reaction at 25 \(^\circ\) C?
   a) 7.1
   b) -3.6
   c) 51
   d) 0.14
   e) 0.37
   \[ 4\text{NO}_2(\text{g}) \rightleftharpoons 2\text{N}_2\text{O}_4(\text{g}) \]

7. Given the following thermochemical data, what is the enthalpy of formation \( \Delta fH^\circ_{298} \) for \( \text{PF}_5(\text{g}) \) at 298 K and 100 kPa?
   a) +582 kJ mol\(^{-1}\)
   b) −1163 kJ mol\(^{-1}\)
   c) −1257 kJ mol\(^{-1}\)
   d) −1594 kJ mol\(^{-1}\)
   e) −2513 kJ mol\(^{-1}\)
   \[ 2\text{P}(s) + 3\text{F}_2(\text{g}) \rightarrow 2\text{PF}_3(\text{g}) \quad \Delta H^\circ = −1838 \text{ kJ mol}^{-1} \]
   \[ \text{PF}_3(\text{g}) + \text{F}_2(\text{g}) \rightarrow \text{PF}_5(\text{g}) \quad \Delta H^\circ = −675 \text{ kJ mol}^{-1} \]

8. What is the oxidation number of Te in \( \text{K}_2\text{H}_4\text{TeO}_6 \)?
   a) +VI
   b) +IV
   c) +II
   d) −IV
   e) −VI

9. Samples of A (4.0 mol) and B (2.0 mol) are placed in a 5.0 L container and the following reaction takes place: \[ 3\text{A}(\text{g}) \rightleftharpoons 2\text{B}(\text{g}) \]
   At equilibrium, the concentration of A is 0.82 M. What is the value of \( K_c \)?
   a) 0.27
   b) 0.31
   c) 2.4
   d) 4.0
   e) 30.

10. For the reaction in question 9, what is the effect of decreasing the volume of the container at constant temperature?
   a) \( K \) increases because the product concentration increases.
   b) \( K \) decreases because the reactant concentration increases.
   c) No change because the reaction does not alter the total number of moles present.
   d) The reaction proceeds towards the products.
   e) The reaction proceeds towards the reactants.

Correct answers: 1A, 2B, 3B, 4C, 5A, 6C, 7D, 8A, 9A, 10D