1. What will happen if the pressure is increased in the following reaction mixture at equilibrium?
\[ \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}^+(\text{aq}) + \text{HCO}_3^-(\text{aq}) \]
A. The equilibrium will shift to the right and pH will decrease.
B. The equilibrium will shift to the right and pH will increase.
C. The equilibrium will shift to the left and pH will increase.
D. The equilibrium will shift to the left and pH will decrease.

2. Consider the equilibrium between \( \text{N}_2\text{O}_4(g) \) and \( \text{NO}_2(g) \).
\[ \text{N}_2\text{O}_4(g) \rightleftharpoons 2\text{NO}_2(g) \Delta H = +58 \text{ kJ mol}^{-1} \]
Which changes shift the position of equilibrium to the right?
I. Increasing the temperature
II. Decreasing the pressure
III. Adding a catalyst
A. I and II only
B. I and III only
C. II and III only
D. I, II and III

3. What is the equilibrium constant expression, \( K_c \), for the following reaction?
\[ 2\text{NH}_3(g) + 2\text{O}_2(g) \rightleftharpoons \text{N}_2\text{O}(g) + 3\text{H}_2\text{O}(g) \]
A. \[ \frac{[\text{NH}_3]^2[\text{O}_2]^2}{[\text{N}_2\text{O}][\text{H}_2\text{O}]^3} \]
B. \[ \frac{[\text{NH}_3][\text{H}_2\text{O}]^3}{[\text{N}_2\text{O}][\text{H}_2\text{O}]^3} \]
C. \[ \frac{[\text{NH}_3]}{[\text{N}_2\text{O}}[\text{H}_2\text{O}]^3 \]
D. \[ [\text{NH}_3]^2[\text{O}_2]^2 \]

4. The enthalpy change for the dissolution of \( \text{NH}_4\text{NO}_3 \) is +26 \text{ kJ mol}^{-1} at 25 °C. Which statement about this reaction is correct?
A. The reaction is exothermic and the solubility decreases at higher temperature.
B. The reaction is exothermic and the solubility increases at higher temperature.
C. The reaction is endothermic and the solubility decreases at higher temperature.
D. The reaction is endothermic and the solubility increases at higher temperature.

5. At 700 °C, the equilibrium constant, \( K_c \), for the reaction is \( 1.075 \times 10^8 \).
\[ 2\text{H}_2(\text{g}) + \text{S}_2(\text{g}) \rightleftharpoons 2\text{H}_2\text{S}(\text{g}) \]
Which relationship is always correct for the equilibrium at this temperature?
A. \([\text{H}_2\text{S}]^2 < [\text{H}_2]^2[\text{S}_2]\]
B. \([\text{S}_2] = 2[\text{H}_2\text{S}]\)
C. \([\text{H}_2\text{S}] < [\text{S}_2]\)
D. \([\text{H}_2\text{S}]^2 < [\text{H}_2]^2[\text{S}_2]\)
6. The graph shows values of Δ\(G\) for a reaction at different temperatures.

Which statement is correct?
A. The standard entropy change of the reaction is negative.
B. The standard enthalpy change of the reaction is positive.
C. At higher temperatures, the reaction becomes less spontaneous.
D. The standard enthalpy change of the reaction is negative.

7. Which variable affects the equilibrium constant, \(K\)?
A. Atmospheric pressure
B. Catalyst
C. Concentration of reactants
D. Temperature

8. Components X and Y are mixed together and allowed to reach equilibrium. The concentrations of X, Y, W and Z in the equilibrium mixture are 4, 1, 4 and 2 mol dm\(^{-3}\) respectively.
\[X + 2Y \rightleftharpoons 2W + Z\]
What is the value of the equilibrium constant, \(K\)?
A. \(\frac{1}{8}\)
B. \(\frac{1}{2}\)
C. 2
D. 8

9. What is the effect of increasing temperature on the equilibrium?
\[\text{ClNO}_2\text{(g)} + \text{NO}\text{(g)} \rightleftharpoons \text{ClNO}\text{(g)} + \text{NO}_2\text{(g)} \quad \Delta H^\circ = -18.4 \text{ kJ}\]

<table>
<thead>
<tr>
<th>Position of equilibrium</th>
<th>(K_o)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. moves to left</td>
<td>decreases</td>
</tr>
<tr>
<td>B. moves to left</td>
<td>no change</td>
</tr>
<tr>
<td>C. moves to right</td>
<td>no change</td>
</tr>
<tr>
<td>D. moves to right</td>
<td>increases</td>
</tr>
</tbody>
</table>
10. What happens when the temperature of the following equilibrium system is increased?

\[
\text{CO(g)} + 2\text{H}_2\text{(g)} \rightleftharpoons \text{CH}_3\text{OH(g)} \quad \Delta H^\circ = -91\text{kJ}
\]

<table>
<thead>
<tr>
<th>Position of equilibrium</th>
<th>Reaction rates of forward and reverse reactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. shifts to the left</td>
<td>increase</td>
</tr>
<tr>
<td>B. shifts to the left</td>
<td>decrease</td>
</tr>
<tr>
<td>C. shifts to the right</td>
<td>decrease</td>
</tr>
<tr>
<td>D. shifts to the right</td>
<td>increase</td>
</tr>
</tbody>
</table>

11. Which is correct for an isolated system in equilibrium?

<table>
<thead>
<tr>
<th>Gibbs free energy</th>
<th>Entropy</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. maximum</td>
<td>maximum</td>
</tr>
<tr>
<td>B. maximum</td>
<td>minimum</td>
</tr>
<tr>
<td>C. minimum</td>
<td>maximum</td>
</tr>
<tr>
<td>D. minimum</td>
<td>minimum</td>
</tr>
</tbody>
</table>

12. A mixture of 0.40 mol of CO (g) and 0.40 mol of H\(_2\) (g) was placed in a 1.00 dm\(^3\) vessel. The following equilibrium was established.

\[
\text{CO (g)} + 2\text{H}_2\text{(g)} \rightleftharpoons \text{CH}_3\text{OH (g)}
\]

At equilibrium, the mixture contained 0.25 mol of CO (g). How many moles of H\(_2\) (g) and CH\(_3\)OH (g) were present at equilibrium?

<table>
<thead>
<tr>
<th>Equilibrium mol of H(_2)</th>
<th>Equilibrium mol of CH(_3)OH</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. 0.25</td>
<td>0.15</td>
</tr>
<tr>
<td>B. 0.50</td>
<td>0.25</td>
</tr>
<tr>
<td>C. 0.30</td>
<td>0.25</td>
</tr>
<tr>
<td>D. 0.10</td>
<td>0.15</td>
</tr>
</tbody>
</table>

13. Which change will favour the reverse reaction in the equilibrium?

\[
2\text{CrO}_4^{2-} \text{(aq)} + 2\text{H}^+ \text{(aq)} \rightleftharpoons \text{Cr}_2\text{O}_7^{2-} \text{(aq)} + \text{H}_2\text{O(l)} \quad \Delta H = -42 \text{kJ}
\]

A. Adding \(\text{OH}^- \text{(aq)}\)
B. Adding \(\text{H}^+ \text{(aq)}\)
C. Increasing the concentration of \(\text{CrO}_4^{2-} \text{(aq)}\)
D. Decreasing the temperature of the solution

\[ \text{CO}(g) + \text{H}_2\text{O}(g) \rightleftharpoons \text{CO}_2(g) + \text{H}_2(g) \]

What is the impact of decreasing the volume of the equilibrium mixture at a constant temperature?
A. The amount of \( \text{H}_2(g) \) remains the same but its concentration decreases.
B. The forward reaction is favoured.
C. The reverse reaction is favoured.
D. The value of \( K_c \) remains unchanged.

15. What is the equilibrium constant expression, \( K_c \), for the formation of hydrogen iodide from its elements?

\[ \text{H}_2(g) + \text{I}_2(g) \rightleftharpoons 2\text{HI}(g) \]

A. \[ K_c = \frac{[\text{HI}]^2}{[\text{H}_2][\text{I}_2]} \]
B. \[ K_c = \frac{2[\text{HI}]}{[\text{H}_2][\text{I}_2]} \]
C. \[ K_c = \frac{2[\text{HI}]^2}{[\text{H}_2][\text{I}_2]} \]
D. \[ K_c = \frac{2[\text{HI}]}{[\text{H}_2][\text{I}_2]} \]

16. Which combination of temperature and pressure will give the greatest yield of sulfur trioxide?

\[ 2\text{SO}_2(g) + \text{O}_2(g) \rightleftharpoons 2\text{SO}_3(g) \quad \Delta H = -196 \text{ kJ} \]

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>low</td>
</tr>
<tr>
<td>low</td>
<td>high</td>
</tr>
<tr>
<td>high</td>
<td>high</td>
</tr>
<tr>
<td>low</td>
<td>low</td>
</tr>
</tbody>
</table>

17. The equation for the reaction between two gases, A and B, is:

\[ 2\text{A}(g) + 3\text{B}(g) \rightleftharpoons \text{C}(g) + 3\text{D}(g) \]

When the reaction is at equilibrium at 600 K the concentrations of A, B, C and D are 2, 1, 3 and 2 \( \text{mol dm}^{-3} \) respectively. What is the value of the equilibrium constant at 600 K?

A. \( \frac{1}{6} \)
B. \( \frac{9}{7} \)
C. 3
D. 6
18. Which equilibrium reaction shifts to the product side when the temperature is increased at constant pressure and to the reactant side when the total pressure is increased at constant temperature?

A. \( \text{N}_2(g) + 3\text{H}_2(g) \rightleftharpoons 2\text{NH}_3(g) \Delta H^\theta < 0 \)
B. \( \text{N}_2\text{O}_4(g) \rightleftharpoons 2\text{NO}_2(g) \Delta H^\theta > 0 \)
C. \( \text{H}_2(g) + \text{I}_2(g) \rightleftharpoons 2\text{HI}(g) \Delta H^\theta < 0 \)
D. \( \text{PCl}_3(g) + \text{Cl}_2(g) \rightleftharpoons \text{PCl}_5(g) \Delta H^\theta > 0 \)

19. Which statement correctly describes the effect of a catalyst on the equilibrium below?

\( \text{N}_2(g) + 3\text{H}_2(g) \rightleftharpoons 2\text{NH}_3(g) \)

A. It increases the rates of both forward and reverse reactions equally.
B. It increases the rate of the forward reaction but decreases the rate of the reverse reaction.
C. It increases the value of the equilibrium constant.
D. It increases the yield of \( \text{NH}_3 \).

20. Which statement is correct for a reversible reaction when \( K_c \gg 1 \)?

A. The reaction almost goes to completion.
B. The reaction hardly occurs.
C. Equilibrium is reached in a very short time.
D. At equilibrium, the rate of the forward reaction is much higher than the rate of the backward reaction.

21. Consider this reaction at equilibrium. \( \text{H}_2\text{S(aq)} + \text{Zn}^{2+}(\text{aq}) \rightleftharpoons \text{ZnS(s)} + 2\text{H}^+(\text{aq}) \Delta H < 0 \)

Which change shifts the equilibrium position to the right?

A. Adding sodium hydroxide
B. Decreasing pressure
C. Adding a catalyst
D. Increasing temperature

22. What is the equilibrium constant expression, \( K_c \), for this reaction?

\( 2\text{NO}(g) + \text{H}_2(g) \rightleftharpoons \text{N}_2\text{O}(g) + \text{H}_2\text{O}(g) \)

A. \( K_c = \frac{[\text{N}_2\text{O}][\text{H}_2\text{O}]}{[2\text{NO}][\text{H}_2]} \)
B. \( K_c = \frac{[\text{NO}][\text{H}_2]}{[\text{N}_2\text{O}][\text{H}_2\text{O}]} \)
C. \( K_c = \frac{[2\text{NO}][\text{H}_2]}{[\text{N}_2\text{O}][\text{H}_2\text{O}]} \)
D. \( K_c = \frac{[\text{N}_2\text{O}][\text{H}_2\text{O}]}{[\text{NO}]^2[\text{H}_2]} \)

23. Which is always correct for a reaction at equilibrium?

<table>
<thead>
<tr>
<th>Concentrations of reactants and products</th>
<th>Rates of forward and reverse reactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. continue to change</td>
<td>equal</td>
</tr>
<tr>
<td>B. remain constant</td>
<td>equal</td>
</tr>
<tr>
<td>C. continue to change</td>
<td>different</td>
</tr>
<tr>
<td>D. remain constant</td>
<td>different</td>
</tr>
</tbody>
</table>
24. A mixture of 2.0 mol of H₂ and 2.0 mol of I₂ is allowed to reach equilibrium in the gaseous state at a certain temperature in a 1.0 dm³ flask. At equilibrium, 3.0 mol of HI are present. What is the value of $K_c$ for this reaction?

\[ \text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g}) \]

\[
K_c = \frac{(3.0)^2}{(0.5)^2}
\]

A. $K_c = \frac{3.0}{(0.5)^2}$
B. $K_c = \frac{(3.0)^2}{(2.0)^2}$
C. $K_c = \frac{(0.5)^2}{(3.0)^2}$
D. $K_c = \frac{(3.0)^2}{(0.5)^2}$

25. Which statements explain why a catalyst is used in the Contact process (shown below)?

\[ \text{SO}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightleftharpoons \text{SO}_3(\text{g}) \]

I. A catalyst lowers the activation energy.
II. A catalyst moves the position of equilibrium towards the product.
III. A catalyst allows the same rate to be achieved at a lower temperature.

A. I and II only
B. I and III only
C. II and III only
D. I, II and III

26. What is the equilibrium constant expression, $K_c$, for the following reaction?

\[ 2\text{H}_2\text{S}(\text{g}) \rightleftharpoons 2\text{H}_2(\text{g}) + \text{S}_2(\text{g}) \]

\[
K_c = \frac{[\text{H}_2\text{S}]^2}{[\text{H}_2]^2[\text{S}_2]}
\]

A. $K_c = \frac{[\text{H}_2\text{S}]^2}{[\text{H}_2]^2[\text{S}_2]}$
B. $K_c = \frac{[\text{H}_2][\text{S}_2]}{[\text{H}_2\text{S}]}$
C. $K_c = \frac{2[\text{H}_2][\text{S}_2]}{[\text{H}_2\text{S}]}$
D. $K_c = \frac{[\text{H}_2]^2[\text{S}_2]}{[\text{H}_2\text{S}]^2}$

27. What happens to the position of equilibrium and the value of $K_c$ in the following reaction when the temperature is decreased?

\[ \text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g}) \quad \Delta H^\Theta = +57.2 \text{ kJ} \]

<table>
<thead>
<tr>
<th>Position of equilibrium</th>
<th>Value of $K_c$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. shifts towards reactants</td>
<td>decreases</td>
</tr>
<tr>
<td>B. shifts towards reactants</td>
<td>increases</td>
</tr>
<tr>
<td>C. shifts towards products</td>
<td>decreases</td>
</tr>
<tr>
<td>D. shifts towards products</td>
<td>increases</td>
</tr>
</tbody>
</table>
28. The value of the equilibrium constant, \( K_c \), for a reaction is \( 1.0 \times 10^{-10} \). Which statement about the extent of the reaction is correct?
   A. The reaction hardly proceeds.
   B. The reaction goes almost to completion.
   C. The products have a higher concentration than the reactants.
   D. The concentrations of reactants and products are the same.

29. Which changes occur when the temperature is decreased in the following equilibrium?
   \[ 2\text{BrCl(g)} \rightleftharpoons \text{Br}_2(g) + \text{Cl}_2(g) \quad \Delta H^\circ = -14 \text{ kJ} \]

<table>
<thead>
<tr>
<th>Position of equilibrium</th>
<th>Value of ( K_c )</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. shifts to the right</td>
<td>decreases</td>
</tr>
<tr>
<td>B. shifts to the right</td>
<td>increases</td>
</tr>
<tr>
<td>C. shifts to the left</td>
<td>decreases</td>
</tr>
<tr>
<td>D. shifts to the left</td>
<td>increases</td>
</tr>
</tbody>
</table>

30. Which statement is correct when the system is at equilibrium at 350 °C?
   A. The concentrations of all reactants and products are equal.
   B. The concentrations of the reactants are greater than the concentration of the product.
   C. The reaction, as written, barely proceeds at this temperature.
   D. The reaction, as written, goes almost to completion at this temperature.

31. Which statement describes and explains the conditions that favour the formation of hydrogen iodide?
   A. Increased temperature as the forward reaction is exothermic, and increased pressure as there are two gaseous reactants and only one gaseous product
   B. Increased temperature as the forward reaction is endothermic, and pressure has no effect as there are equal amounts, in mol, of gaseous reactants and products
   C. Decreased temperature as the forward reaction is exothermic, and decreased pressure as there are two moles of gaseous product but only one mole of each gaseous reactant
   D. Decreased temperature as the forward reaction is exothermic, and pressure has no effect as there are equal amounts, in mol, of gaseous reactants and products

32. Which of the following will shift the position of equilibrium to the right in the Haber process?
   \[ \text{N}_2(g) + 3\text{H}_2(g) \rightleftharpoons 2\text{NH}_3(g) \quad \Delta H^\circ = 92.6 \text{ kJ} \]
   I. Decreasing the concentration of \( \text{NH}_3(g) \)
   II. Decreasing the temperature
   III. Increasing the pressure
   A. I and II only
   B. I and III only
   C. II and III only
   D. I, II and III

33. What is the relationship between \( pK_a \), \( pK_b \), and \( pK_w \) for a conjugate acid–base pair?
   A. \( pK_a = pK_w + pK_b \)
   B. \( pK_a = pK_w - pK_b \)
   C. \( pK_a \times pK_b = pK_w \)
   D. \( pK_b = pK_w \)
34. When gaseous nitrosyl chloride, NOCl (g), decomposes, the following equilibrium is established:
2NOCl(g) ⇌ 2NO(g) + Cl2(g)
2.0 mol of NOCl(g) were placed in a 1.0 dm³ container and allowed to reach equilibrium. At equilibrium 1.0 mol of NOCl(g) was present. What is the value of $K_c$?
A. 0.50
B. 1.0
C. 1.5
D. 2.0

35. Consider the following reaction:
2A ⇌ C $K_c = 1.1$
Which statement is correct when the reaction is at equilibrium?
A. [A] ≫ [C]
B. [A] > [C]
C. [A] = [C]
D. [A] < [C]

36. Iron(III) ions, Fe³⁺, react with thiocyanate ions, SCN⁻, in a reversible reaction to form a red solution. Which changes to the equilibrium will make the solution go red?
Fe³⁺(aq) + SCN⁻(aq) ⇌ [FeSCN]²⁺(aq) $\Delta H^\circ$ = +ve
Yellow     Red
I. Increasing the temperature
II. Adding FeCl₃
III. Adding a catalyst
A. I and II only
B. I and III only
C. II and III only
D. I, II and III

37. What is the equilibrium constant expression, $K_c$, for the following reaction?
2NOBr(g) ⇌ 2NO(g) + Br₂(g)

A. $K_c = \frac{[NO][Br_2]}{[NOBr]}$
B. $K_c = \frac{[NO]^2[Br_2]}{[NOBr]^2}$
C. $K_c = \frac{2[NO + Br_2]}{[2NOBr]}$
D. $K_c = \frac{[NOBr]^2}{[NO]^2[Br_2]}$
38. What happens to the position of equilibrium and the value of $K_c$ when the temperature is increased in the following reaction?

$$\text{PCl}_3(g) \rightleftharpoons \text{PCl}_3(g) + \text{Cl}_2(g) \quad \Delta H^\theta = +87.9 \text{ kJ mol}^{-1}$$

<table>
<thead>
<tr>
<th>Position of equilibrium</th>
<th>Value of $K_c$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. shifts towards reactants</td>
<td>decreases</td>
</tr>
<tr>
<td>B. shifts towards reactants</td>
<td>increases</td>
</tr>
<tr>
<td>C. shifts towards products</td>
<td>decreases</td>
</tr>
<tr>
<td>D. shifts towards products</td>
<td>increases</td>
</tr>
</tbody>
</table>

39. Which are characteristics of a dynamic equilibrium?
I. Amounts of products and reactants are constant.
II. Amounts of products and reactants are equal.
III. The rate of the forward reaction is equal to the rate of the backward reaction.
A. I and II only
B. I and III only
C. II and III only
D. I, II and III

40. The following are $K_c$ values for a reaction, with the same starting conditions carried out at different temperatures. Which equilibrium mixture has the highest concentration of products?

A. $1 \times 10^{-2}$
B. 1
C. $1 \times 10^1$
D. $1 \times 10^2$

41. Consider the reaction between gaseous iodine and gaseous hydrogen.

$$\text{I}_2(g) + \text{H}_2(g) \rightleftharpoons 2\text{HI}(g) \quad \Delta H^\theta = -9 \text{ kJ}$$

Why do some collisions between iodine and hydrogen not result in the formation of the product?
A. The $\text{I}_2$ and $\text{H}_2$ molecules do not have sufficient energy.
B. The system is in equilibrium.
C. The temperature of the system is too high.
D. The activation energy for this reaction is very low.

42. The equilibrium between nitrogen dioxide, $\text{NO}_2$, and dinitrogen tetroxide, $\text{N}_2\text{O}_4$, is shown below.

$$2\text{NO}_2(g) \rightleftharpoons \text{N}_2\text{O}_4(g) \quad K_c = 0.01$$

What happens when the volume of a mixture at equilibrium is decreased at a constant temperature?
I. The value of $K_c$ increases
II. More $\text{N}_2\text{O}_4$ is formed
III. The ratio of $\frac{[\text{NO}_2]}{[\text{N}_2\text{O}_4]}$ decreases
A. I and II only
B. I and III only
C. II and III only
D. I, II and III
43. Which statement about chemical equilibria implies they are dynamic?
A. The position of equilibrium constantly changes.
B. The rates of forward and backward reactions change.
C. The reactants and products continue to react.
D. The concentrations of the reactants and products continue to change.

44. For the following reaction \( K_c = 1.0 \times 10^{-5} \) at 30 °C.
\[ 2\text{NOCl}(g) \rightleftharpoons 2\text{NO}(g) + \text{Cl}_2(g) \]
Which relationship is correct at equilibrium at this temperature?
A. The concentration of NO equals the concentration of NOCl.
B. The concentration of NOCl is double the concentration of Cl\(_2\).
C. The concentration of NOCl is much greater than the concentration of Cl\(_2\).
D. The concentration of NO is much greater than the concentration of NOCl.

45. The reaction below represents the Haber process for the industrial production of ammonia.
\[ \text{N}_2(g) + 3\text{H}_2(g) \rightleftharpoons 2\text{NH}_3(g) \quad \Delta H^\circ = -92 \text{ kJ} \]
The optimum conditions of temperature and pressure are chosen as a compromise between those that favour a high yield of ammonia and those that favour a fast rate of production. Economic considerations are also important. Which statement is correct?
A. A higher temperature would ensure higher yield and a faster rate.
B. A lower pressure would ensure a higher yield at a lower cost.
C. A lower temperature would ensure a higher yield and a faster rate.
D. A higher pressure would ensure a higher yield at a higher cost.

46. What is the equilibrium constant expression for the reaction below?
\[ 2\text{NO}_2(g) \rightleftharpoons \text{N}_2\text{O}_4(g) \]

47. The formation of nitric acid, \( \text{HNO}_3(\text{aq}) \), from nitrogen dioxide, \( \text{NO}_2(\text{g}) \), is exothermic and is a reversible reaction.
\[ 4\text{NO}_2(g) + \text{O}_2(g) + 2\text{H}_2\text{O}(l) \rightleftharpoons 4\text{HNO}_3(\text{aq}) \]
What is the effect of a catalyst on this reaction?
A. It increases the yield of nitric acid.
B. It increases the rate of the forward reaction only.
C. It increases the equilibrium constant.
D. It has no effect on the equilibrium position.

48. What is the equilibrium constant expression, \( K_c \), for the following reaction?
\[ \text{N}_2\text{O}_4(g) \rightleftharpoons 2\text{NO}_2(g) \]
49. Consider the endothermic reaction below. 
\[ 5\text{CO}(g) + \text{I}_2\text{O}_5(g) \rightleftharpoons 5\text{CO}_2(g) + \text{I}_2(g) \]
According to Le Chatelier’s principle, which change would result in an increase in the amount of \( \text{CO}_2 \)?
A. Increasing the temperature
B. Decreasing the temperature
C. Increasing the pressure
D. Decreasing the pressure

50. What is the effect of an increase of temperature on the yield and the equilibrium constant for the following reaction?
\[ 2\text{H}_2(g) + \text{CO}(g) \rightleftharpoons \text{CH}_3\text{OH}(l) \quad \Delta H^\Theta = -128 \text{ kJ} \]

<table>
<thead>
<tr>
<th>Yield</th>
<th>Equilibrium constant</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Increases</td>
<td>Increases</td>
</tr>
<tr>
<td>B. Increases</td>
<td>Decreases</td>
</tr>
<tr>
<td>C. Decreases</td>
<td>Increases</td>
</tr>
<tr>
<td>D. Decreases</td>
<td>Decreases</td>
</tr>
</tbody>
</table>

51. An increase in temperature increases the amount of chlorine present in the following equilibrium.
\[ \text{PCl}_5(s) \rightleftharpoons \text{PCl}_3(l) + \text{Cl}_2(g) \]
What is the best explanation for this?
A. The higher temperature increases the rate of the forward reaction only.
B. The higher temperature increases the rate of the reverse reaction only.
C. The higher temperature increases the rate of both reactions but the forward reaction is affected more than the reverse.
D. The higher temperature increases the rate of both reactions but the reverse reaction is affected more than the forward.

52. What will happen when at a constant temperature, more iodide ions, \( \text{I}^- \), are added to the equilibrium below?
\[ \text{I}_2(s) + \text{I}^- (aq) \rightleftharpoons \text{I}_3^- (aq) \]
A. The amount of solid iodine decreases and the equilibrium constant increases.
B. The amount of solid iodine decreases and the equilibrium constant remains unchanged.
C. The amount of solid iodine increases and the equilibrium constant decreases.
D. The amount of solid iodine increases and the equilibrium constant remains unchanged.

53. Consider the following equilibrium reaction. 
\[ 2\text{SO}_2(g) + \text{O}_2(g) \rightleftharpoons 2\text{SO}_3(g) \quad \Delta H^\Theta = -197 \text{ kJ} \]
Which change in conditions will increase the amount of \( \text{SO}_3 \) present when equilibrium is re-established?
A. Decreasing the concentration of \( \text{SO}_2 \)
B. Increasing the volume
C. Decreasing the temperature
D. Adding a catalyst
54. What effect will an increase in temperature have on the $K_c$ value and the position of equilibrium in the following reaction?

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta H = -92 \text{ kJ}$$

<table>
<thead>
<tr>
<th>$K_c$</th>
<th>Equilibrium position</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. increases</td>
<td>shifts to the right</td>
</tr>
<tr>
<td>B. decreases</td>
<td>shifts to the left</td>
</tr>
<tr>
<td>C. increases</td>
<td>shifts to the left</td>
</tr>
<tr>
<td>D. decreases</td>
<td>shifts to the right</td>
</tr>
</tbody>
</table>

55. Which statement is always correct for a chemical reaction at equilibrium?
A. The rate of the forward reaction equals the rate of the reverse reaction.
B. The amounts of reactants and products are equal.
C. The concentration of the reactants and products are constantly changing.
D. The forward reaction occurs to a greater extent than the reverse reaction.

56. Consider the following reversible reaction.

$$\text{Cr}_2\text{O}_7^{2-}(aq) + \text{H}_2\text{O}(l) \rightleftharpoons 2\text{CrO}_4^{2-}(aq) + 2\text{H}^+(aq)$$

What will happen to the position of equilibrium and the value of $K_c$ when more $\text{H}^+$ ions are added at constant temperature?

<table>
<thead>
<tr>
<th>Position of equilibrium</th>
<th>Value of $K_c$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. shifts to the left</td>
<td>decreases</td>
</tr>
<tr>
<td>B. shifts to the right</td>
<td>increases</td>
</tr>
<tr>
<td>C. shifts to the right</td>
<td>does not change</td>
</tr>
<tr>
<td>D. shifts to the left</td>
<td>does not change</td>
</tr>
</tbody>
</table>

57. Which statement is correct for the equilibrium $\text{H}_2\text{O}(l) \rightleftharpoons \text{H}_2\text{O}(g)$ in a closed system at 100 °C?
A. All the $\text{H}_2\text{O}(l)$ molecules have been converted to $\text{H}_2\text{O}(g)$.
B. The rate of the forward reaction is greater than the rate of the reverse reaction.
C. The rate of the forward reaction is less than the rate of the reverse reaction.
D. The pressure remains constant.

58. The indicator, HIn is used in a titration between an acid and base. Which statement about the dissociation of the indicator, HIn is correct?

$$\text{HIn}(aq) \rightleftharpoons \text{H}^+(aq) + \text{In}^-(aq)$$

<table>
<thead>
<tr>
<th>colour A</th>
<th>colour B</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. In a strongly alkaline solution, colour B would be observed.</td>
<td></td>
</tr>
<tr>
<td>B. In a strongly acidic solution, colour B would be observed.</td>
<td></td>
</tr>
<tr>
<td>C. $[\text{In}^-]$ is greater than $[\text{HIn}]$ at the equivalence point.</td>
<td></td>
</tr>
<tr>
<td>D. In a weakly acidic solution colour B would be observed.</td>
<td></td>
</tr>
<tr>
<td></td>
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<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td>6</td>
<td>B</td>
</tr>
<tr>
<td>11</td>
<td>C</td>
</tr>
<tr>
<td>16</td>
<td>B</td>
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<tr>
<td>21</td>
<td>A</td>
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<td>31</td>
<td>D</td>
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<td>36</td>
<td>A</td>
</tr>
<tr>
<td>41</td>
<td>A</td>
</tr>
<tr>
<td>46</td>
<td>D</td>
</tr>
<tr>
<td>51</td>
<td>C</td>
</tr>
<tr>
<td>56</td>
<td>D</td>
</tr>
</tbody>
</table>