Chemistry

Higher level

Paper 1A

Practice paper

Topic: Equilibrium

Chemistry

Higher level

Paper 1A

Specimen paper

1 hour

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all questions.
- For each question, choose the best answer.
- A clean copy of the chemistry data booklet is required.
- The maximum mark for this paper is [30 marks].

Section A

1. Which expression relates the standard Gibbs free energy change ($\Delta G^{\ominus}$) to the equilibrium constant (K)?
   A. $\Delta G^{\ominus} = RT \ln K$
   B. $\Delta G^{\ominus} = -RT \ln K$
   C. $\Delta G^{\ominus} = -RT\, e^{K}$
   D. $\ln K = \Delta G^{\ominus} / RT$

2. If $\Delta G^{\ominus}$ for a reaction is a large negative value, what can be stated about the equilibrium constant K?
   A. K is close to 1.
   B. K is a very small number ($K << 1$).
   C. K is a very large number ($K >> 1$).
   D. K is negative.

3. A reaction reaches equilibrium. If the reaction quotient, Q_c, is found to be greater than K_c, what will happen?
   A. The reaction will shift to the right to produce more products.
   B. The reaction will shift to the left to produce more reactants.
   C. The reaction will stop completely.
   D. The value of K_c will decrease to equal Q_c.

4. Consider the reaction $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ ($\Delta H < 0$). How does an increase in temperature affect the values of K_c and the forward rate constant k_f?
   A. K_c increases, k_f increases
   B. K_c decreases, k_f increases
   C. K_c decreases, k_f decreases
   D. K_c increases, k_f decreases

5. Which adjustment will change the numerical value of the equilibrium constant, K_c?
   A. Adding a catalyst
   B. Decreasing the volume
   C. Adding more reactant
   D. Decreasing the temperature

6. Reaction 1 has $K_c = X$. Reaction 2 is formed by reversing Reaction 1 and multiplying the coefficients by 2. What is the K_c for Reaction 2?
   A. -2X
   B. 1 / (2X)
   C. $1 / X^2$

D. X^2

7. For the equilibrium $N_2O_4(g) \rightleftharpoons 2NO_2(g)$, $K_c = 0.5$ at a specific temperature. If the equilibrium concentration of NO_2 is 2.0 mol dm^{-3}, what is the equilibrium concentration of N_2O_4?

A. 8.0 mol dm^{-3}
B. 4.0 mol dm^{-3}
C. 2.0 mol dm^{-3}
D. 1.0 mol dm^{-3}

8. In an ICE table (Initial, Change, Equilibrium), what parameter dictates the algebraic stoichiometric ratio of the 'Change' row?

A. The magnitude of the initial concentrations.
B. The coefficients of the balanced chemical equation.
C. The temperature of the system.
D. The value of K_c.

9. For the reaction $A(g) + 2B(g) \rightleftharpoons C(g)$, $K_c = 50$. If 1 mol of A and 2 mol of B are placed in a 1 dm^3 flask, the equilibrium concentration of C will be:

A. Exactly 1 mol dm^{-3}
B. Close to 1 mol dm^{-3}
C. Exactly 50 mol dm^{-3}
D. Close to 0 mol dm^{-3}

10. For a gaseous reaction where $\Delta n > 0$ (more moles of gas on products side), separating K_p and K_c: $K_p = K_c(RT)^{\Delta n}$. This means at standard conditions:

A. $K_p = K_c$
B. $K_p > K_c$
C. $K_p < K_c$
D. K_p is unrelated to K_c

11. Why does an inert gas added at constant volume not alter the equilibrium position of a gaseous reaction?

A. It does not change the partial pressures of the reacting gases.
B. It acts as a catalyst.
C. It expands the volume of the container.
D. It prevents collisions between reacting molecules.

12. What distinguishes a homogeneous equilibrium from a heterogeneous equilibrium?

A. One involves only solutions, the other only gases.

B. One has all species in the same physical state, the other has species in different states.
C. One responds to temperature changes, the other responds to pressure changes.
D. One reaches equilibrium quickly, the other slowly.

13. If K_c is approximately 10^{-5}, the position of equilibrium:
A. Lies far to the right.
B. Lies far to the left.
C. Is perfectly central.
D. Cannot be determined.

14. When two separate reactions are added together to form a third overall reaction, the equilibrium constant of the third reaction is:
A. The sum of the two individual constants.
B. The product of the two individual constants.
C. The difference of the two individual constants.
D. The average of the two individual constants.

15. For an endothermic reaction, increasing the temperature results in:
A. A more negative $\Delta G^{\ominus}$ and a larger K.
B. A more negative $\Delta G^{\ominus}$ and a smaller K.
C. A more positive $\Delta G^{\ominus}$ and a larger K.
D. A more positive $\Delta G^{\ominus}$ and a smaller K.

16. Solid carbon and oxygen gas react to form carbon dioxide: $C(s) + O_2(g) \rightleftharpoons CO_2(g)$. The correct equilibrium expression is:
A. $K_c = [CO_2] / ([C][O_2])$
B. $K_c = [CO_2] / [O_2]$
C. $K_c = [C][O_2] / [CO_2]$
D. $K_c = [CO_2]$

17. The vapor pressure of water at exactly 100 degrees C is 1 atm. For the equilibrium $H_2O(l) \rightleftharpoons H_2O(g)$ at this temperature, $\Delta G^{\ominus}$ is:
A. > 0
B. < 0
C. 0
D. 1

18. A reaction has $K = 1 \times 10^3$ at 298 K. What is the approximate value of $\Delta G^{\ominus}$ in kJ mol^{-1}? (Use $R \approx 8.3$ J K^{-1} mol^{-1})

A. +17
B. -17
C. -17000
D. +17000

19. Which statement is true for an equilibrium mixture when a catalyst is added?
A. The activation energy of the forward reaction alone is reduced.
B. The rate of the forward reaction increases more than the reverse.
C. The rates of both the forward and reverse reactions are increased equally.
D. The value of K_c increases.

20. In an equilibrium graph of concentration vs time, a sudden sharp vertical drop in the line for one reactant indicates:
A. An increase in temperature.
B. A decrease in pressure.
C. The sudden physical removal of that reactant from the container.
D. The addition of a catalyst.

21. A reaction has $\Delta H < 0$ and $\Delta S < 0$. At low temperatures, K is:
A. > 1
B. < 1
C. 1
D. 0

22. If a system starts with $Q_c = 0$, the reaction must:
A. Shift left.
B. Shift right.
C. Be at equilibrium.
D. Be an irreversible reaction.

23. Which factors determine the magnitude of K_c for a specific reaction?
I. Temperature
II. Initial concentrations
III. The balanced chemical equation
A. I and II only
B. I and III only
C. II and III only
D. I, II and III

24. Which of the following result from increasing the total pressure (by compression) on the equilibrium $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$?

I. The value of K_c remains constant.
II. The equilibrium shifts to the right.
III. The yield of ammonia decreases.
A. I and II only
B. I and III only
C. II and III only
D. I, II and III

25. Regarding the relationship $\Delta G^{\ominus} = -RT \ln K$, which are true?

I. When $K > 1$, $\Delta G^{\ominus}$ is negative.
II. When $K = 1$, $\Delta G^{\ominus}$ is zero.
III. When $K < 1$, the forward reaction is non-spontaneous under standard conditions.
A. I and II only
B. I and III only
C. II and III only
D. I, II and III

26. Which changes occur when an inert gas is added at constant pressure to an equilibrium mixture consisting of reacting gases?

I. The volume of the system increases.
II. The partial pressures of the reacting gases decrease.
III. The equilibrium position shifts towards the side with more moles of gas.
A. I and II only
B. I and III only
C. II and III only
D. I, II and III

27. For a saturated aqueous solution of an ionic salt at equilibrium, what happens if water evaporates?

I. More salt precipitates.
II. The concentration of dissolved ions increases.
III. The K_sp value changes.
A. I only
B. I and II only
C. II and III only
D. I, II and III

28. During an ICE table calculation to find equilibrium concentrations from K_c, when is it valid to assume the 'change in x' is mathematically negligible?

I. When K_c is extremely small (e.g., $< 10^{-4}$).
II. When initial reactant concentrations are very large relative to K_c.
III. When K_c is extremely large.
A. I and II only
B. I and III only
C. II and III only
D. I, II and III

29. Which properties define a dynamic equilibrium?
I. It can only be reached from the reactant side.
II. It requires a closed system.
III. The macroscopic properties are constant.
A. I and II only
B. I and III only
C. II and III only
D. I, II and III

30. Which modifications would cause the reaction quotient Q_c to instantly become smaller than K_c?
I. Removing a product
II. Adding a reactant
III. Increasing the temperature of an endothermic equilibrium
A. I and II only
B. I and III only
C. II and III only
D. I, II and III