EASE 4 CHEMISTRY GRADE 11

Multiple Choice
Identify the choice that best completes the statement or answers the question.

1. **Which statements about reversible reactions are correct?**

   1   An increase in concentration of a reactant always increases the concentration of the product.
   2   An increase in temperature always increases the rate at which the equilibrium is established.
   3   An increase in temperature always increases the concentration of the product at equilibrium.

   A) 1, 2 and 3   **C)** 2 and 3
   B) 1 and 2   **D)** 1 only

2. Two compounds X and Y react to produce compound Z. The reaction is reversible.

   $$X + Y \rightleftharpoons Z$$

   When X and Y are mixed together in a closed system a dynamic equilibrium is gradually established.

   Which graph could represent the change in the rates of the forward and reverse reactions over time?
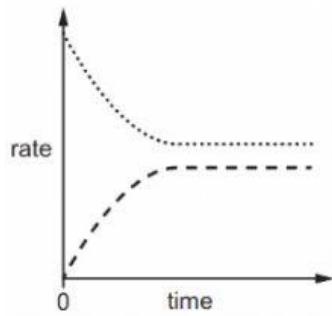
   **A)**   **C)**
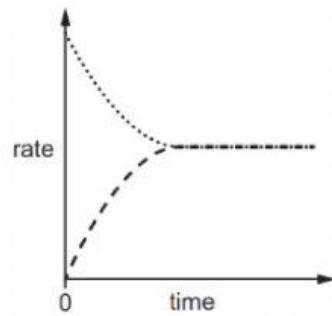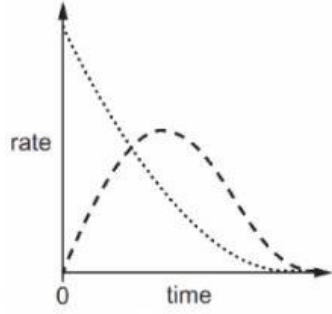
   B)   **D)**
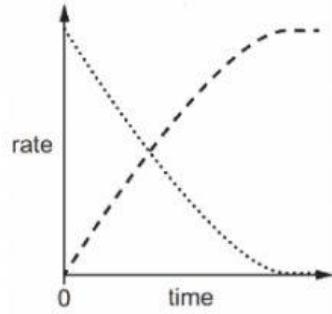
3. When gaseous iodine is heated with hydrogen at 450 °C, an equilibrium is established.

$$H_2(g) \quad + \quad I_2(g) \quad \rightleftharpoons \quad 2HI(g) \qquad \Delta H = +53 \text{ kJ/mol}$$

  colourless   purple   colourless

Which change of conditions will cause the purple colour of the equilibrium mixture to become paler?

A) decrease in pressure
B) decrease in temperature

C) increase in pressure
D) increase in temperature

4. Hydrogen iodide gas decomposes reversibly producing iodine vapour and hydrogen.

$$2HI(g) \rightleftharpoons I_2(g) + H_2(g) \quad \Delta H = +12 \text{ kJ mol}^{-1}$$
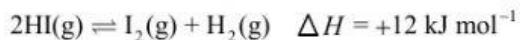
The position of the equilibrium for this reaction may be altered by changing the external conditions.

Which row correctly describes the change in position of equilibrium?

	effect of increasing the pressure	effect of increasing the temperature
A	moves to the right	moves to the right
B	moves to the right	moves to the left
C	no change	moves to the right
D	no change	moves to the left

A) A
B) B

C) C
D) D

5. The equation represents an equilibrium.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \quad \Delta H = -900 \text{ kJ mol}^{-1}$$
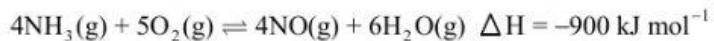
What would increase the concentration of NO at equilibrium?

1 a reduction in the reaction temperature
2 the use of a suitable catalyst
3 an increase in the total pressure

A) 1, 2 and 3
B) 1 and 2

C) 2 and 3
D) 1 only

6. X and Y react together to form Z in a reversible reaction.

   The equilibrium yield of Z is lower at higher temperature.

   The equilibrium yield of Z is lower at lower pressure.

   **Which equation could be represent this reaction?**

   A) $X(g) + Y(g) \rightleftharpoons Z(g)$ $\triangle H = -100$ kJ   **C)** $X(s) + Y(g) \rightleftharpoons 2Z(g)$ $\triangle H = -100$ kJ
   mol^{-1} mol^{-1}

   B) $X(g) + Y(g) \rightleftharpoons Z(g)$ $\triangle H = +100$ kJ   **D)** $X(s) + Y(g) \rightleftharpoons 2Z(g)$ $\triangle H = +100$ kJ
   mol^{-1} mol^{-1}

7. The decomposition of $SO_3(g)$ is a dynamic equilibrium.

$$2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$$

   What happens when the pressure of the system is increased?

   A) The rate of reaction will decrease and the position of the equilibrium will move to the left.

   B) The rate of reaction will decrease and the position of the equilibrium will move to the right.

   C) The rate of reaction will increase and the position of the equilibrium will move to the left.

   D) The rate of reaction will increase and the position of the equilibrium will move to the right.

8. Ammonia is manufactured from nitrogen and hydrogen using the Haber process.
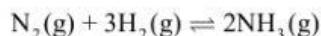
$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

   What is the expression for K_c for this equilibrium?

   A) $\dfrac{2[NH_3(g)]}{[N_2(g)] + 3[H_2(g)]}$

   B) $\dfrac{2[NH_3(g)]}{[N_2(g)] \times 3[H_2(g)]}$

   C) $\dfrac{[NH_3(g)]^2}{[N_2(g)] + [H_2(g)]^3}$

   D) $\dfrac{[NH_3(g)]^2}{[N_2(g)] \times [H_2(g)]^3}$

9. **What is the correct expression for K_c for the reaction shown?**

$$I_2(aq) + 2Fe^{2+}(aq) \rightleftharpoons 2I^-(aq) + 2Fe^{3+}(aq)$$
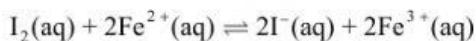
A) $\dfrac{[2I^-][2Fe^{3+}]}{[I_2][2Fe^{2+}]}$

C) $\dfrac{[I_2][2Fe^{2+}]}{[2I^-][2Fe^{3+}]}$

B) $\dfrac{[I^-]^2[Fe^{3+}]^2}{[I_2][Fe^{2+}]^2}$

D) $\dfrac{[I_2][Fe^{2+}]^2}{[I^-]^2[Fe^{3+}]^2}$

10. The unit of K_c for an equilibrium reaction are $mol^{-1}dm^3$.

    What could be the equation for the equilibrium?

    1   $A(aq) + B(aq) \rightleftharpoons C(s) + D(aq)$

    2   $P(aq) + Q(aq) \rightleftharpoons R(aq)$

    3   $W(aq) + 2X(aq) \rightleftharpoons Y(aq) + Z(aq)$

   A) 1, 2 and 3   C) 2 and 3

    B) 1 and 2   D) 1 only

11. When copper is added to a solution of silver ions, the following equilibrium is established.

$$Cu(s) + 2Ag^+(aq) \rightleftharpoons Cu^{2+}(aq) + 2Ag(s) \quad K_c = 1.0 \times 10^5$$
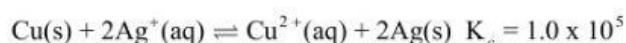
    What is the concentration of silver ions at equilibrium when $[Cu^{2+}] = 0.10$ mol dm^{-3}?

    A) 5.0×10^{-7} mol dm^{-3} C) 1.0×10^{-3} mol dm^{-3}

    B) 5.0×10^{-4} mol dm^{-3} D) 1.0×10^{2} mol dm^{-3}

12. The reaction between sulfur dioxide and oxygen is reversible.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \quad K_c = 280 \; mol^{-1}dm^3 \text{ at } 1000 \text{ K}$$
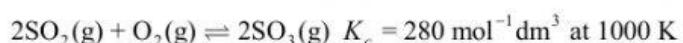
    In an equilibrium mixture at 1000 K the sulfur trioxide concentration is 6.00 mol dm^{-3}.

    The sulfur dioxide concentration is twice the oxygen concentration.

    What is the sulfur dioxide concentration?

    A) 0.175 mol dm^{-3} C) 0.318 mol dm^{-3}

    B) 0.254 mol dm^{-3} D) 0.636 mol dm^{-3}

13. The reaction between sulfur dioxide and oxygen is reversible.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \quad K_c = 280 \text{ mol}^{-1}\text{dm}^3 \text{ at 1000 K}$$
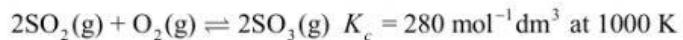
In an equilibrium mixture at 1000 K the sulfur dioxide concentration is 0.200 mol dm^{-3} and the oxygen concentration is 0.100 mol dm^{-3}.

What is the sulfur trioxide concentration?

A) 1.058 mol dm^{-3} C) 2.366 mol dm^{-3}

B) 1.120 mol dm^{-3} D) 5.600 mol dm^{-3}

14. Ethyl ethanoate undergoes the following reaction.

$$CH_3CO_2C_2H_5 + H_2O \rightleftharpoons C_2H_5OH + CH_3CO_2H \quad K_c = 0.27$$
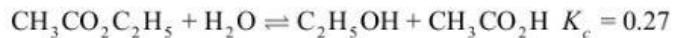
Equal amounts of ethanoic acid and ethanol were mixed together and allowed to reach equilibrium.

At equilibrium, the concentrations of both ethanoic acid and ethanol were 0.42 mol dm^{-3}.

What is the concentration of ethyl ethanoate at equilibrium?

A) 0.22 mol dm^{-3} C) 0.81 mol dm^{-3}

B) 0.65 mol dm^{-3} D) 1.54 mol dm^{-3}

15. In this question you should assume that all gases behave ideally.

Hydrogen and iodine react reversibly in the following reaction. The system reaches dynamic equilibrium.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \quad \Delta H = -9.5 \text{ kJ mol}^{-1}$$
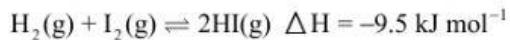
Which statement must be true for the K_p of this equilibrium to be constant?

A) The partial pressure of H$_2$, I$_2$ and HI are equal.   C) The forward and reverse reactions have stopped.

B) The external pressure is constant.   D) The temperature is constant.

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16. The table gives the partial pressure of the gases when the following equilibrium is reached.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$
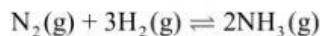
	N_2	H_2	NH_3
partial pressure	1	9	1

What is the numerical value of the equilibrium constant, K_p?

A) $\dfrac{1}{729}$

C) $\dfrac{1}{9}$

B) $\dfrac{1}{27}$

D) 9

17. The manufacture of ammonia from nitrogen and hydrogen is an important industrial process.

Which of the following would leave the equilibrium constant, K_p, for the formation of ammonia unchanged?

    1   addition of an iron catalyst
    2   addition of ammonia
    3   an increase in pressure

A) 1, 2 and 3

C) 2 and 3

B) 1 and 2

D) 1 only

18. The gases X and Y react to form Z.

$$X(g) + Y(g) \rightleftharpoons Z(g)$$
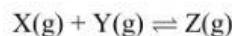
An equilibrium mixture of these three gases is compressed at constant temperature.

What will be the changes in the mole fraction of Z and in K_p?

	mole fraction of Z	K_p
A	increase	increase
B	increase	no change
C	no change	increase
D	no change	no change

A) A

C) C

B) B

D) D

19. Ammonia is manufactured on a large scale by the Haber process.

In a particular plant, conditions of 400 °C and 250 atm in the presence of an iron catalyst are used.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta H = -92 \text{ kJ mol}^{-1}$$
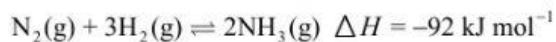
What could contribute most to increasing the equilibrium yield of ammonia?

A) adding more catalyst   C) increasing the temperature to 1000 °C
B) increasing the pressure to 400 atm   D) using air rather than nitrogen

20. Nitrogen and hydrogen can react together to form ammonia.

The formation of ammonia is exothermic.

The rate and yield of the reaction can be altered by changing the conditions under which the reaction is carried out.

Which row shows the effects of adding iron to the mixture and increasing the temperature?

	adding iron	increasing the temperature
A	has no effect on the equilibrium yield	reduces the equilibrium yield
B	increases the equilibrium yield	increases the equilibrium yield
C	increases the equilibrium yield	increases the rate
D	increases the rate	has no effect on the equilibrium yield

A) A   C) C
B) B   D) D

21. The following shows the reaction in aqueous solution.

$$CH_3COOH + NH_3 \rightleftharpoons CH_3COO^- + NH_4^+$$

Which of the following give the correct acid reactant and its conjugate base product?

	acid reactant	conjugate base
1	CH_3COOH	CH_3COO^-
2	CH_3COOH	NH_4^+
3	NH_3	CH_3COO^-
4	NH_3	NH_4^+

A) 1   C) 3
B) 2   D) 4

22. **Which statements are correct in terms of the Brønsted-Lowry theory of acids and bases?**

1 Water can act as either an acid or a base.
2 Sulfuric acid does not behave as an acid when dissolved in ethanol.
3 The ammonium ion acts as a base when dissolved in liquid ammonia.

A) 1, 2 and 3   C) 2 and 3
B) 1 and 2   D) 1 only

23. **Which statement about the ammonium ion is correct?**

A) It can act as a Brønsted-Lowry base.   C) It is pyramidal with bond angles of 107°.

B) It can react with OH^- to give ammonia.   D) The nitrogen atom is sp^2 hybridised.

24. Hydrated aluminium ions undergo the following reaction.

$$[Al(H_2O)_6]^{3+}(aq) + H_2O(l) \rightleftharpoons [Al(H_2O)_5OH]^{2+}(aq) + H_3O^+(aq)$$

Which statement about this reaction is correct?

A) $H_2O(l)$ and $[Al(H_2O)_5OH]^{2+}(aq)$ are a   C) if $OH^-(aq)$ is added, the equilibrium
   conjugate acid-base pair.   will move to the right.

B) $H_2O(l)$ is acting as an acid as it is   D) K_c varies as the pH is varied.
   donating H^+ ions.

25. The ionic product of water, K_w, varies with temperature as shown in the following table.

temperature/ °C	K_w/mol^2 dm^{-6}
25	1.0×10^{-14}
62	1.0×10^{-13}

What conclusion can be drawn from this information?

A) Water is not a neutral liquid at $62°C$.

B) The ionic dissociation of water is an endothermic process.

C) The ionic dissociation of water increases by factor of 5 between $25°C$ and $62°C$.

D) The association of water molecules by hydrogen bonding increases as temperature rises.

26. Water dissociates as follows:

$$H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq) \quad \triangle H = +57.2 \text{ kJ mol}^{-1} \text{ at 298 K}$$

The ionic product of water, K_w, is defines as:

$$[H^+][OH^-] = 1.0 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6} \text{ at 298 K}$$

What deductions be made from these information?

1 When water is heated, the concentration of $H^+(aq)$ increases.
2 When water is heated, the concentration of $OH^-(aq)$ increases.
3 The pH of pure water at temperature greater than $25°C$ is greater than 7.

A) 1, 2 and 3
B) 1 and 2
C) 2 and 3
D) 1 only

27. **Which of the following is the pH of a solution of magnesium hydroxide containing 4.0×10^{-5} mol dm^{-3} of hydroxide ions at 298K?**

$K_w = 1.0 \times 10^{-14}$ mol^2 dm^{-6}

A) 9.6
B) 9.5
C) 8.6
D) 8.3