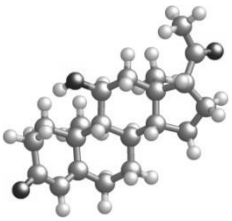

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Name: …… **( )**

Class: ……

Date: …… **/** …… **/** ……

Questions on Reversible Reactions

• Write your answers to the multiple-choice questions in the table given on the right:

1.		**2.**		**3.**		**4.**	
5.		**6.**		**7.**		**8.**	

1. The equation below shows the reversible reaction that occurs when the weak acid, H_2CO_3, dissociates in water:

$$H_2CO_3(aq) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$$

Which of the following will cause the equilibrium to shift to the left?

A Adding hydrochloric acid into the solution.
B Bubbling carbon dioxide gas into the solution.
C Adding a substance that reacts with HCO_3^- ions.
D Adding aqueous sodium hydroxide into the solution.

2. In which of the following reactions will an increase in pressure in the reaction chamber **not** cause a change in the equilibrium position?

A $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
B $NH_3(g) + HCl(g) \rightleftharpoons NH_4Cl(s)$
C $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$
D $SOCl_2(g) + H_2O(g) \rightleftharpoons SO_2(g) + 2HCl(g)$

3. The reaction between ethene and hydrogen gas can be expressed in the equation below:

$$C_2H_4(g) + H_2(g) \rightleftharpoons C_2H_6(g)$$

How does increasing the pressure affect the rate of the forward and backward reactions?

	forward reaction	backward reaction
A	increases	increases
B	increases	decreases
C	decreases	increases
D	decreases	decreases

4. When iron(II) ions are added to silver ions, an equilibrium mixture is formed.

$$Fe^{2+}(aq) + Ag^+(aq) \rightleftharpoons Fe^{3+}(aq) + Ag(s)$$

How can the amount of silver solid in the equilibrium mixture be increased?

A Decreasing the concentration of the aqueous Fe^{2+} ions.
B Decreasing the concentration of the aqueous Ag^+ ions.
C Decreasing the concentration of the aqueous Fe^{3+} ions.
D Increasing the concentration of the aqueous Fe^{3+} ions.

5. Study the equilibrium system given below:

$$\underset{\text{orange dichromate(VI)}}{Cr_2O_7^{2-}(aq)} + H_2O(l) \rightleftharpoons \underset{\text{yellow chromate(VI)}}{2CrO_4^{2-}(aq)} + 2H^+(aq)$$

With reference to the following equilibrium, which one of the following statements is correct?

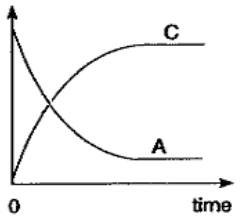
A Adding water to an aqueous solution of yellow potassium chromate(VI) will make it turn orange.
B Orange potassium dichromate(VI) will dissolve in sulfuric acid to produce a yellow solution.
C When aqueous sodium hydroxide is added to an aqueous solution of potassium dichromate(VI), the solution will become lighter in colour.
D Pure solid potassium dichromate(VI) does not exist because of the above equilibrium.

6. An equal number of moles of chemical **A** and chemical **B** were reacted together until the system reached equilibrium:

$$\mathbf{A}(g) + \mathbf{B}(g) \rightleftharpoons \mathbf{C}(g) + \mathbf{D}(g)$$

Which graph is most likely to show the progress of the reaction?

A



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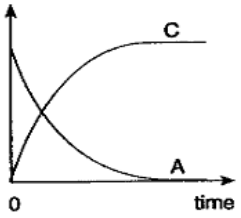

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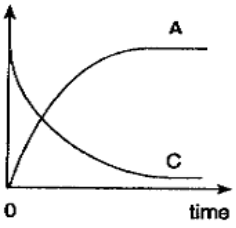

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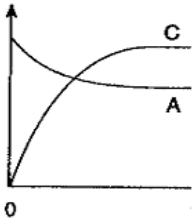


7. Which one of the following conditions would increase the yield of ammonia for the reaction below?

$$2NO_2(g) + 7H_2(g) \rightleftharpoons 4H_2O(l) + 2NH_3(g) \quad \Delta H = -432 \text{ kJ mol}^{-1}$$

A Increase pressure.
B Increase temperature.
C Decrease volume of NO_2 used.
D Add a catalyst.

8. The balanced chemical equation below shows the equilibrium formed between $[Co(H_2O)_6]^{2+}$ and $[Co(Cl)_4]^{2-}$:

$$\underset{\text{pink}}{[Co(H_2O)_6]^{2+}(aq)} + 4Cl^-(aq) \rightleftharpoons \underset{\text{blue}}{[Co(Cl)_4]^{2-}(aq)} + 6H_2O(l) \qquad \Delta H \text{ is positive}$$

Which of the following changes will cause the above equilibrium mixture to turn pink?

I Decreasing the temperature.
II Adding silver nitrate solution.
III Increasing the volume of the container.

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

Structured Questions

1. When a chemical system is in equilibrium, a simple relationship known as the equilibrium law exists between the molar concentrations of the products and the reactants. For the reaction:

$$a\mathbf{A} + b\mathbf{B} \rightleftharpoons c\mathbf{C} + d\mathbf{D}$$

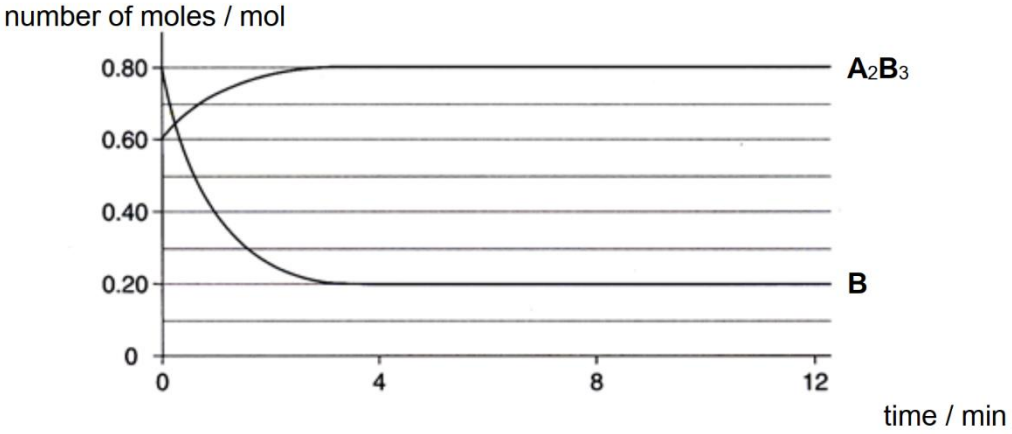
The equilibrium constant, K_c, for the reaction is written as:

$$K_c = \frac{[\mathbf{C}]^c \times [\mathbf{D}]^d}{[\mathbf{A}]^a \times [\mathbf{B}]^b}$$

K_c is the equilibrium constant for the reaction expressed in terms of concentrations.
[ ] denotes the concentration of the chemicals expressed in mol dm^{-3}.
A reversible reaction involving $\mathbf{A}_2$, **B** and $\mathbf{A}_2\mathbf{B}_3$ is shown below.

$$\mathbf{A}_2(g) + 3\mathbf{B}(g) \rightleftharpoons \mathbf{A}_2\mathbf{B}_3(g)$$

In one experiment, $\mathbf{A}_2(g)$, **B**(g) and $\mathbf{A}_2\mathbf{B}_3(g)$ were introduced into a 4.0 dm^3 container at 900 K. The graph for the number of moles of **B**(g) and $\mathbf{A}_2\mathbf{B}_3(g)$ against time is given below:



(a) If 0.5 mol of $\mathbf{A}_2(g)$ were initially added to the reaction container, then sketch the expected curve to show how moles of $\mathbf{A}_2(g)$ change during the course of the reaction.

(b) Write an expression for the equilibrium constant, K_c, for the formation of $\mathbf{A}_2\mathbf{B}_3(g)$ from $\mathbf{A}_2(g)$ and **B**(g).

K_c = _____

(c) K_c has a value of 190 at 900 K and 64 000 at 500 K. Explain whether the reaction to produce $\mathbf{A}_2\mathbf{B}_3(g)$ is exothermic or endothermic.

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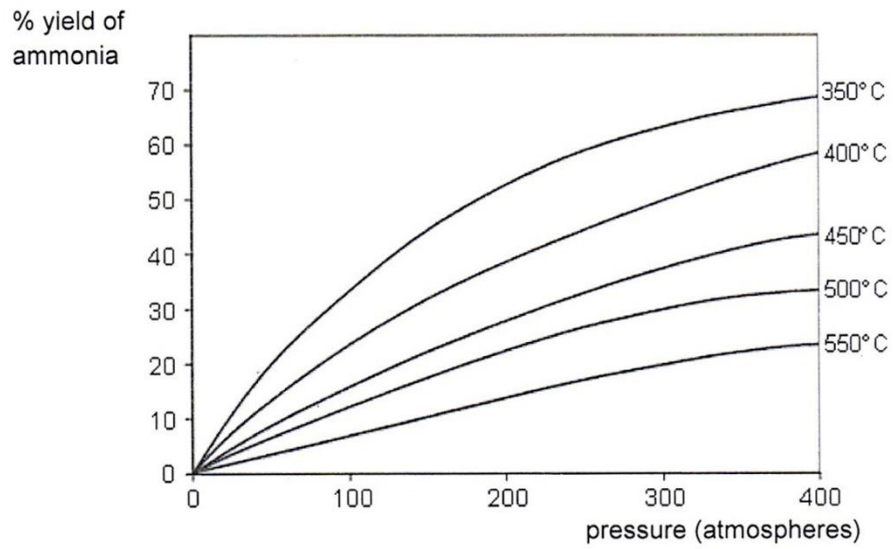
2. The graph below shows the percentage yield of ammonia formed in the equilibrium mixture under the different conditions of temperature and pressure in the Haber process.



The balanced chemical equation for the reaction is given below.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(a) With reference to the graph, is the formation of ammonia an endothermic or exothermic reaction? Explain your answer.

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(b) With reference to the graph, how does increasing the pressure of the system affect the yield of ammonia? Explain your answer.

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3. Haemoglobin, Hb, is a type of molecule found in red blood cells that can bind to oxygen molecules to form oxyhaemoglobin, $Hb(O_2)_4$, according to the following equation:

$$Hb(aq) + 4O_2(aq) \rightleftharpoons Hb(O_2)_4(aq)$$

(a) Using Le Chatelier's Principle, state what happens to the position of the equilibrium when red blood cells are circulated through the lungs which are rich in dissolved oxygen.

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(b) Where there are high levels of carbon dioxide, the following reactions occur:

$$H_2O(l) + CO_2(g) \rightleftharpoons H^+(aq) + HCO_3^-(aq) \textbf{ – (1)}$$

$$Hb(O_2)_4(aq) + H^+(aq) \rightleftharpoons HHb^+(aq) + 4O_2(aq) \textbf{ – (2)}$$

(i) With reference to equations **(1)** and **(2)**, use Le Chatelier's Principle to explain the effect of high levels of carbon dioxide on the concentration of dissolved oxygen in the blood.

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(ii) Explain why this system of equilibria is essential for cells in bodily tissues.

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4. Limescale is the chalky deposit of calcium carbonate, $CaCO_3(s)$, found in kettles and hot water pipes where *hard water* has evaporated. *Hard water* contains calcium hydrogen carbonate, $Ca(HCO_3)_2(aq)$, and the equation below shows the equilibrium between dissolved calcium hydrogen carbonate, dissolved calcium carbonate and dissolved carbon dioxide gas.

$$Ca^{2+}(aq) + 2HCO_3^-(aq) \rightleftharpoons Ca^{2+}(aq) + CO_3^{2-}(aq) + CO_2(aq) + H_2O(l)$$

Heating water causes dissolved carbon dioxide to be removed from water.
Using Le Chatelier's Principle, predict and explain the effect of heating water on the formation of limescale.

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5. *Acidity regulators* are food additives that have a buffering action on the pH of food. A buffer solution is a solution whose pH remains almost unchanged when a little acid or alkali is added to it.

Mixtures of citric acid, $C_5H_7O_4COOH$, and sodium citrate, $C_5H_7O_4COO^-Na^+$, are often used to make acidity regulators. The equation below shows the reversible ionisation of citric acid in the citric acid / sodium citrate buffer system:

$$C_5H_7O_4COOH \rightleftharpoons C_5H_7O_4COO^-(aq) + H^+(aq)$$

Using Le Chatelier's Principle, explain how the citric acid / sodium citrate buffer system regulates the pH of food when:

(a) $H^+(aq)$ ions are added.

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(b) $OH^-(aq)$ ions are added.

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6. The hydrogen carbonate ion plays a role in the marine ecosystem. Shells of some sea creatures are made of calcium carbonate, which is vulnerable to acidity levels in the sea, as seen in the two equations given below:

Equation **1**: $CaCO_3(s) \rightleftharpoons Ca^{2+}(aq) + CO_3^{2-}(aq)$

Equation **2**: $CO_3^{2-}(aq) + H^+(aq) \rightleftharpoons HCO_3^-(aq)$

By considering Le Chatelier's Principle, and with reference to **both** equations, explain a possible effect of increased acidity in seawater on the shells of these creatures.

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+ + + End of Assignment + + +

- Scan the QR code below to view the answers to this assignment.

http://www.chemist.sg/ammonia_equilibrium/equilibrium_assignment_ans.pdf