CHEMISTRY 2021

Unit 3
Key Topic Test 6 – Equilibrium Systems

Recommended writing time*: 45 minutes
Total number of marks available: 50 marks

SOLUTIONS

SECTION A: Multiple-choice questions (1 mark each)

Question 1

Answer: B

Explanation:

The equilibrium lies well to the right for the Hb and CO reaction so it has a much higher equilibrium constant than the Hb and O_2 reaction. This stops O_2 from reaching the cells.

Question 2

Answer: D

Explanation:

The equilibrium shifts right when the reaction mixture is heated. Therefore, the reaction is endothermic and K will increase.

Question 3

Answer: C

Explanation:

The concentration of F_2 suddenly drops, indicating that some of it has been removed. The reaction is endothermic so a decrease in temperature shifts the equilibrium to the left.

Question 4

Answer: B

Explanation:

The first level part of the graph where the concentration of all species is constant occurs at the 10 second mark.

Question 5

Answer: B

Explanation:

For an exothermic reaction, a higher yield is obtained at a lower temperature. And as there are fewer mole of products that reactants (2 mol vs 3 mol), a high pressure also favours the products.

Question 6

Answer: B

Explanation:

As heat is produced by the reaction, it is exothermic. Decreasing the temperature favours the products for an exothermic reaction. Adding an inert gas does not affect the position of equilibrium and decreasing the pressure will favour the reactants.

Question 7

Answer: B

Explanation:

Adding an extra reactant will push the equilibrium to the right, increasing the concentration of PCl_3. The value of K will not change and the rate of reaction will not increase as there is no overall increase in pressure.

Question 8

Answer: D

Explanation:

The addition of an inert gas will not have any effect on the rate or position of equilibrium.

Question 9

Answer: A

Explanation:

By carrying out the reaction in a well-ventilated environment, you have an "open system" where the carbon dioxide can move away from the reaction mixture. Or, the carbon dioxide is removed from the products as it is a gas, shifting the equilibrium to the right.

Question 10

Answer: D

Explanation:

For each molecule of C_2H_2 that forms from C_2H_6, two molecules of H_2 form. So, the concentration of C_2H_2 is half the concentration of H_2.

SECTION B: Short-answer questions

Question 1

a.

Action taken	Equilibrium shift (left or right)	Effect on reaction rate (increase or decrease)	Effect on the value of K (increase, no change or decrease)
Increase in temperature	*Right*	*Increase*	*Increase*
Addition of Fe^{3+} ions	*Right*	*Increase*	*No change*
Removal of SCN^- ions	*Left*	*Decrease*	*No change*
Addition of water	*Left*	*Decrease*	*No change*

12 marks

b. $Kc = [FeSCN^{2+}] / [Fe^{2+}][SCN^-]$ *
$138 = 1.00 / x^2$ (the concentration of both ions are the same) *
$X^2 = 1/138 = 0.007246$
$X = 0.0851\ M^{-1}$ *

3 marks
Total 15 marks

Question 2

a. **i.** increase
ii. decrease

1 + 1 = 2 marks

b. exothermic

1 mark

c. Increasing the pressure favours the side with the least number of mole of gas.* To partly compensate for the increase in concentration the system adjusts to produce fewer particles.*

2 marks

d. The line should be steeper (reaches equilibrium more quickly) and should return to the same level (concentration) of the original line.

1 mark
Total 6 marks

Question 3

a. Increase in temperature – the rate increase, the yield decreases.
Increase in pressure – the rate increases, the yield increases**.**

4 marks

b. The temperature chosen needs to be a compromise between rate and yield. A moderate temperature might be chosen which provides a fast enough rate with an acceptable yield.

2 marks

c. A heterogeneous catalyst would enable the gases to be passed over it.

1 mark
Total 7 marks

Question 4

a. 8-16 min, 24-32 min

1 mark

b. Temperature decrease

1 mark

c. $K_c = [AB_2]^2 [B_2] / [AB_3]^2$

1 mark

d. $K_c = 1.6^2 \times 0.8 / 8.4^2 * = 0.029M^{-1} *$

2 marks

e. **i.** no change
ii. decrease

1 + 1 = 2 marks
Total 7 marks

Question 5

a.

	$ClNO_2$	NO	NO_2	ClNO
I	3.5	1.2		
C	0.2	0.2	0.2	0.2
E	3.3	1.0 *	0.2	0.2 *

$K_c = [NO_2] [ClNO] / [ClNO_2] [NO] *$
$K_c = 0.2 \times 0.2 / 3.3 \times 1.0$
$K_c = 0.04 / 3.3$
$K_c = 0.012 *$

4 marks

b. No shift in equilibrium (same number of mole on both sides of the equation)

1 mark
Total 5 marks