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VCE Chemistry $\frac{3}{4}$
Equilibrium [2.7]
Test Solutions

20 Marks. 1 Minute Reading. 16 Minutes Writing.

Results:

Test Questions	_____ / 15
Extension	_____ / 5



Section A: Test Questions (15 Marks)

Question 1 (4 marks)

Tick whether the following statements are **true** or **false**.

Statement	True	False
a. If a reaction is reversible, this means that both the forward and backward reactions occur at the same time.	<input checked="" type="checkbox"/>	
b. In VCE chemistry, we study equilibria occurring in open systems.		<input checked="" type="checkbox"/>
c. A dynamic equilibrium is established when the forward and backward reactions occur at the same rate and subsequently stop reacting.		<input checked="" type="checkbox"/>
d. The K_c value gives you the ratio of the concentration of reactants to the concentration of products.		<input checked="" type="checkbox"/>
e. Equilibria in which solids and liquids are present are assigned a 'concentration' value of 1, and consequently ignored in K_c and Q_c expressions.	<input checked="" type="checkbox"/>	
f. If a particular reaction has a large extent of reaction, its Q_c value will be high.		<input checked="" type="checkbox"/>
g. If the Q_c value is less than the K_c value, the rate of the forward reaction will be greater than the rate of the reverse reaction until equilibrium is established.	<input checked="" type="checkbox"/>	
h. RICE tables are used to find the moles of each reactant and product at equilibrium, and then these values are directly plugged into the K_c expression to obtain the equilibrium constant.		<input checked="" type="checkbox"/>

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Question 2 (6 marks)

Henry is investigating the reaction between nitrogen and oxygen to produce nitrogen monoxide:



- a. Explain what can be said about the extent of the reaction above at 25°C . Justify your answer with reference to the position of equilibrium. (2 marks)

$K_c < 10^{-4}$ so, the reaction shown occurs to a small extent (1). This means that at equilibrium, there are much more reactants present than products; the position of equilibrium lies to the left/towards the reactants (2).

b.

- i. Calculate the K_c value for the reaction, $\text{NO}(\text{g}) \rightleftharpoons \frac{1}{2}\text{N}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g})$ at 25°C . (1 mark)

$$K_{c(\text{new})} = \frac{1}{\sqrt{K_{c(\text{old})}}} = \frac{1}{\sqrt{2.2 \times 10^{-5}}} \\ = 2.13 \text{ (no unit) (3 sf)}$$

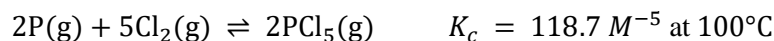
- ii. For the reaction provided in **part b. i.** if the reaction takes place in a 2.00 L vessel and $[\text{NO}] = 2.30 \times 10^2 \text{ M}$ and $[\text{O}_2] = 1.80 \times 10^3 \text{ M}$ at equilibrium, calculate the amount, in M mol , of N_2 which must be present in the vessel when the rates of the forward and reverse reactions are equal. (3 marks)

$$K_c = \frac{[\text{N}_2]^{\frac{1}{2}} [\text{O}_2]^{\frac{1}{2}}}{[\text{NO}]} \\ 213.2 = \frac{[\text{N}_2]^{\frac{1}{2}} (1.8 \times 10^3)^{\frac{1}{2}}}{2.3 \times 10^2}$$

$$\Rightarrow [\text{N}_2] = \left(\frac{213.2 \times 2.3 \times 10^2}{(1.8 \times 10^3)^{\frac{1}{2}}} \right)^2 \\ = 1.336 \times 10^6 \text{ M} \\ n(\text{NO}) = cV = 1.336 \times 10^6 \times 2.00 = 2.67 \times 10^6 \text{ mol} \\ = 2.67 \text{ M mol}$$

Question 3 (5 marks)

The following reversible reaction is being investigated in a laboratory:



The reaction was initiated by mixing 2.32 mol of phosphorus with 5.27 mol of chlorine in a sealed, 5.00 L evacuated vessel at 100°C. 10 minutes into the reaction, it is observed that the concentration of PCl₅ is 0.333 M.

- a. Calculate the reaction quotient for this reaction once 10 minutes have elapsed. (3 marks)

	$2\text{P(g)} + 5\text{Cl}_2\text{(g)} \rightleftharpoons 2\text{PCl}_5\text{(g)}$		
$n_i \text{ (mol)}$	2.32	5.27	0
$n_c \text{ (mol)}$	-1.665	-4.1625	+1.665
$n_{10 \text{ mins}} \text{ (mol)}$	0.655	1.1075	1.665
$c_{10 \text{ mins}} \text{ (M)}$	0.131	0.2215	0.333
$Q_c = \frac{[\text{PCl}_5]^2}{[\text{P}]^2 [\text{Cl}_2]^5} = \frac{0.333^2}{0.131^2 \cdot 0.2215^5} = 1.21 \times 10^4 \text{ M}^{-5}$			

- b. State whether the system is at equilibrium 10 minutes into the reaction or not. If not, explain how the reactions will progress towards equilibrium. (1 mark)

$Q_c \neq K_c \rightarrow$ system is not at equilibrium. Since $Q_c > K_c$, the system will favour the backwards reaction in order to establish equilibrium.

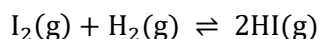
- c. Had this reaction occurred in a compressed, 1.00 L vessel (still at 100°C), predict the effect this would have had on the equilibrium constant. (1 mark)

No effect $\rightarrow K_c$ value for a particular reaction is ONLY impacted by a change in temperature.

Section B: Extension (5 Marks)

Question 4 (5 marks)

Anika is investigating the production of hydrogen iodide via the reversible reaction between gaseous iodine and hydrogen in a closed vessel of volume V litres, according to the following equation:



The K_c value for this reaction is 26.9 at 300°C .

- a. Given that Anika placed 3.20 mol of both $\text{H}_2(\text{g})$ and $\text{I}_2(\text{g})$ into the empty container at 300°C , calculate the amount of HI , in mol , that would have been present at equilibrium. (4 marks)

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

$n_i (\text{mol})$	3.20	3.20	0
$n_c (\text{mol})$	$-x$	$-x$	$+2x$
$n_e (\text{mol})$	$3.20-x$	$3.20-x$	$2x$
$c_e (\text{M})$	$\frac{3.20-x}{V}$	$\frac{3.20-x}{V}$	$\frac{2x}{V}$

$$K_c = \frac{[\text{HI}]^2}{[\text{I}_2][\text{H}_2]} = \frac{\left(\frac{2x}{V}\right)^2}{\left(\frac{3.20-x}{V}\right)^2}$$

$$26.9 = \frac{\left(\frac{2x}{3.20-x}\right)^2}{1}$$

$$\Rightarrow 5.186(3.20-x) = 2x$$

$$16.6 - 5.186x = 2x$$

$$\Rightarrow 7.186x = 16.6$$

$$\Rightarrow x = 2.31 \text{ mol}$$

$$\therefore n_e(\text{HI}) = 2x = 2 \times 2.31 = 4.62 \text{ mol}$$

- b. Anika decides to conduct the same experiment at a slightly cooler temperature to ensure her safety and calculates the system's reaction quotient (Q_c) after 5 minutes, obtaining a value of 26.9. Explain what Anika may conclude about the position of equilibrium in this instance. (1 mark)

— Cannot conclude anything as we do not know the K_c value at this new temperature.
 — Therefore, we have nothing to compare the calculated Q_c value to, so we are unsure as to where the position of equilibrium lies.

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