Worksheet 6.1

Changing the position of equilibrium

NAME: **CLASS:**

INTRODUCTION

The equilibrium constant indicates the extent of a chemical reaction; the larger the value, the further to the right the reaction proceeds and so the more product is formed. It is possible to manipulate the position of equilibrium, and so the amount of product obtained, by varying the conditions under which a reaction is performed. Le Châtelier's principle is useful in determining how reactions may be manipulated to our benefit. His principle may be stated as follows:

> *If a system is at equilibrium and any of the temperature, pressure or concentrations of the species are changed, the reaction will proceed in such a direction as to partially compensate for this change.*

No.	Question	Answer
1	For each of the following reactions, determine the effect of increasing the temperature on: **i** the position of equilibrium **ii** the equilibrium constant. **a** $2H_2O(g) \rightleftharpoons 2H_2(g) + O_2(g)$; $\Delta H = +484$ kJ mol^{-1} **b** $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$; $\Delta H = -92.3$ kJ mol^{-1} **c** $N_2O_4(g) \rightleftharpoons 2NO_2(g)$; $\Delta H = +58$ kJ mol^{-1}	
2	State the direction in which the equilibrium position would move after the addition of hydrogen gas, for each of the following reactions: **a** $C_2H_4(g) + H_2(g) \rightleftharpoons C_2H_6(g)$ **b** $CH_3OH(aq) \rightleftharpoons CO(g) + 2H_2(g)$ **c** $H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g)$	
3	What, if any, will be the effect on the position of equilibrium for the reaction below if inert nitrogen gas is added to the reaction vessel at constant volume? $2H_2S(g) \rightleftharpoons 2H_2(g) + S_2(g)$	

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4	In the industrial production of nitric acid, the following reaction occurs to oxidise ammonia to nitrogen monoxide: $4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$; $\Delta H = -907$ kJ mol^{-1} Choose the appropriate option in each case to generate the maximum possible yield. **a** Increase/decrease temperature. **b** Increase/decrease pressure. **c** Add/remove NO.	
5	Copper metal reacts exothermically with 8 mol L^{-1} nitric acid to produce nitrogen monoxide: $3Cu(s) + 8HNO_3(aq) \rightleftharpoons 3Cu(NO_3)_2(aq) + 4H_2O(l) + 2NO(g)$ Which of the following measures would force the equilibrium position to the right? Explain your choices. **a** Use a more concentrated acid. **b** Use a catalyst. **c** Heat the mixture. **d** Remove NO as it is formed.	
6	'The corrosion of iron is a very slow process and so the reaction below must have a small equilibrium constant.' $4Fe(s) + 3O_2(g) \rightleftharpoons 2Fe_2O_3(s)$ Is this statement accurate? Explain your answer in terms of both rate and equilibrium.	
7	For each of the following aqueous equilibrium systems, determine the overall direction in which the reaction will proceed if the volume of the solution is doubled by adding water to the reaction vessel. **a** $Fe^{3+}(aq) + 4Cl^-(aq) \rightleftharpoons [FeCl_4]^-(aq)$ **b** $Cu^{2+}(aq) + Fe^{2+}(aq) \rightleftharpoons Cu^+(aq) + Fe^{3+}(aq)$	

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8	When oxygen gas is reacted with hydrogen bromide, bromine gas is produced and heat is evolved: $4HBr(g) + O_2(g) \rightleftharpoons Br_2(g) + 2H_2O(g)$; $\Delta H = -155$ kJ mol^{-1} Predict the effect on the equilibrium position *and* the equilibrium constant of the following changes. **a** Extra HBr is added to the container. **b** The vessel is heated. **c** Some unreactive argon gas is pumped into the container at fixed volume. **d** The volume of the reaction vessel is decreased. **e** A catalyst is used.	
9	Acetic acid ionises in water according to the following equation: $CH_3COOH(aq) + H_2O(l) \rightleftharpoons CH_3COO^-(aq) + H_3O^+(aq)$ State the effect on the concentration of the $H_3O^+(aq)$ ion if a small amount of sodium acetate was added to the equilibrium mixture.	
10	Consider the graph of concentration versus time shown below for the following reaction: $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ Show the changes that would occur in the concentrations of all three species if the volume of the reaction vessel was suddenly increased.