CHEM 3AB EQUILIBRIUM Assignment (Foundations of Chemistry)

1 CO and Cl_2 are mixed in a flask so their concentrations are 0.400 mol L^{-1}

12 Consider the following reaction at equilibrium.

$$O_3(g) + NO(g) \rightleftharpoons O_2(g) + NO_2(g)$$

How would the concentrations of each of these substances change if:

a The concentration of O_3 was increased.
b The partial pressure of NO_2 was increased.
c The concentration of NO was decreased.
d The partial pressure of O_2 was decreased.

13 For the equilibrium

$$4HBr(g) + O_2(g) \rightleftharpoons 2H_2O(g) + 2Br_2(g)$$

predict the effect of the following changes on the concentrations of each of the substances.

a Decreasing the volume of the system.
b Decreasing the external pressure on the system.
c Adding some of the noble gas helium to the system but keeping the volume constant.

14 **a** Predict the effect of increasing the temperature of the following equilibrium systems.

i $3O_2(g) + 286\ kJ \rightleftharpoons 2O_3(g)$
ii $2CO(g) + O_2(g) \rightleftharpoons 2CO_2(g) + 566\ kJ$

b Predict the effect of decreasing the temperature of the following equilibrium systems

i $N_2(g) + 2O_2(g) + 66\ kJ \rightleftharpoons 2NO_2(g)$
ii $2NO(g) + 2H_2(g) \rightleftharpoons N_2(g) + 2H_2O(g) + 664\ kJ$

15 If the reaction

$$Ca(HCO_3)_2(s) + \text{heat} \rightleftharpoons CaO(s) + 2CO_2(g) + H_2O(g)$$

is at equilibrium, predict the effects of the following changes on the concentration and mass of each substance present.

a Increasing the concentration of CO_2.
b Decreasing the partial pressure of H_2O.
c Decreasing the external pressure.
d Increasing the mass of CaO.
e Decreasing the temperature.

16 Consider the following reaction at equilibrium.

$$SO_2(g) + NO_2(g) \rightleftharpoons SO_3(g) + NO(g) + 42\ kJ$$

If the following changes are made to the system

a The SO_2 concentration is increased.
b The pressure is increased.
c The volume is increased.
d The temperature is increased.
e A catalyst is added.

i Predict the effect on the concentrations of each substance and explain your prediction.
ii Describe what happens to the rates of the forward and reverse reactions.

17 Methanol, a useful fuel and solvent, can be manufactured from hydrogen and carbon monoxide

$$2H_2(g) + CO(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H = -90\ kJ$$

a What conditions would favour a fast reaction rate for this reaction?

System A: $[PCl_5] = 0.025$ mol L^{-1}, $[Cl_2] = 0.040$ mol L^{-1}

b What conditions would favour a high equilibrium yield of methanol?
c Is it likely that compromise conditions would be needed in an industrial process based on this reaction?

18 **a** Write an equation for the equilibrium between solid NaCl and its saturated aqueous solution.

b If HCl gas is bubbled through saturated NaCl solution the gas dissolves to form H^+ and Cl^- ions but some NaCl crystallises from the solution. Use Le Chatelier's principle to explain the reduced solubility of NaCl in HCl solution.

19 When the equilibrium system

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

is heated, the equilibrium constant increases. Predict whether the forward reaction is exothermic or endothermic and explain your prediction.

20 The following system is at equilibrium.

$$Ag^+(aq) + 2NH_3(aq) \rightleftharpoons [Ag(NH_3)_2]^+(aq)$$

When iodide ions are added silver iodide precipitates. Predict the effect this will have on the ammonia concentration.