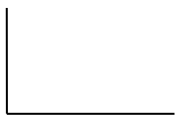
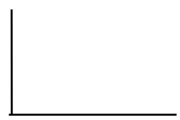
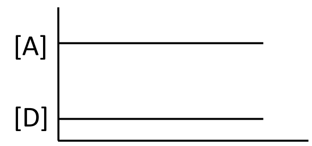
CHEMISTRY 12 – UNIT II – EQUILIBRIUM

F: Dynamic Equilibrium (The Quantitative Approach) *It is expected that students will be able to…*

F1: The Equilibrium Constant - Gather and interpret data on the concentration of reactants and products of a system at equilibrium

1) Using the information given for each reversible reaction, for a) and b) sketch a concentration vs time graph for each situation as it reaches equilibrium. For c) determine the equilibrium chemical equation.

a) $X_{(g)} \rightleftharpoons Z_{(g)}$; $K_{eq} = 6.8$ In a closed system, a certain amount of Z is added. 	b) $K_{eq} = \frac{[H_2][I_2]}{[HI]^2} = 0.42$ In a closed system, a certain amount of HI is added. 	c) The K_{eq} for a reaction is 3.1×10^2. Using the sketch below, write out the possible reaction: 

F2: The Equilibrium Expression - Write the expression for the equilibrium constant when given the equation for either a homogeneous or heterogeneous equilibrium system

1) Write out the Equilibrium Expression (K_{eq}) for the following equilibrium reactions:

a) $4NH_{3(g)} + 5O_{2(g)} \rightleftharpoons 4NO_{(g)} + 6H_2O_{(g)}$

b) $3Ca^{+2}_{(aq)} + 2NO_3^-{}_{(aq)} + 3Li^+_{(aq)} + 2PO_4^{-3}{}_{(aq)} \rightleftharpoons Ca_3(PO_4)_{2(s)} + 3Li^+_{(aq)} + 2NO_3^-{}_{(aq)}$

c) $4NpF_{3(s)} + O_{2(g)} + 4HF_{(aq)} \rightleftharpoons 4NpF_{4(s)} + H_2O_{(l)}$

F3 & F4: Le Chatelier's Principle - Relate the equilibrium position to the value of Keq and predict the effect (or lack of effect) on the value of Keq

1) For the following system at equilibrium: $\mathbf{CuSO_{4(s)} \rightleftharpoons Cu^{+2}_{(aq)} + SO_4^{-2}_{(aq)}}$ **, ΔH = -17kJ**;

determine what will happen to the equilibrium system when each of the stress listed below is applied.

i) State the direction of shift (if applicable) and describe how the forward and reverse reactions rates change as equilibrium is re-established and describe how the concentrations/amounts of each chemical species will change as the system returns to equilibrium.

ii) State whether this stress affects the value of Keq (will the value increase, decrease or stay the same).

a) A solution containing concentration copper(II) ions is added:

b) The volume of the container is increased:

c) Some of the copper(II) sulphate is removed:

d) The system is placed in an ice bath:

2) For the following reaction: $\mathbf{A_{(g)} \rightleftharpoons B_{(g)}}$ **K_{eq} = 4.2**

Determine whether the equilibrium is exothermic or endothermic. When the equilibrium system is placed on a hot plate and allowed to return to equilibrium, it was determined that the K_{eq} = 1.3 at this new temperature.

F5: Equilibrium Stoichiometry - Calculate the value of Keq given the equilibrium concentration of all species or use Keq to calculate an unknown concentration at equilibrium.

1) Using the following system at equilibrium: $\mathbf{4NH_{3(g)} + 5O_{2(g)} \rightleftharpoons 4NO_{(g)} + 6H_2O_{(g)}}$ **,** What is the value of K_{eq} if the concentrations for each particle were found to be:

$4NH_{3(g)}$	+	$5O_{2(g)}$	$\rightleftharpoons$	$4NO_{(g)}$	+	$6H_2O_{(g)}$
0.40M		1.1M		0.25M		0.66M

2) For the following equilibrium reaction: $\mathbf{2HI_{(g)} \rightleftharpoons H_{2(g)} + I_{2(g)}}$ **;** $\mathbf{K_{eq} = 0.21}$**,** If the equilibrium concentrations for $[H_2]$ and $[I_2]$ are 0.55M, what is the [HI] at equilibrium?

F6: Equilibrium Stoichiometry – As a reversible reaction reaches equilibrium. Calculate the value of Keq given the initial concentrations of all species and one equilibrium concentration.

1) Using the following reversible reaction: $\mathbf{H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}}$ **;** Initially, a 5.0 L reaction vessel is filled with 2.0 moles of hydrogen gas and 2.0 moles of iodine gas. When the system reaches equilibrium, the [HI] is 0.50M. What is the value of the equilibrium constant?

F6: Equilibrium Stoichiometry – As a reversible reaction reaches equilibrium. Calculate the value of Keq given the initial concentrations of all species and one equilibrium concentration. (Part II)

1) Using the following reversible reaction: $\mathbf{2F_{2(g)} + S_{2(g)} \rightleftharpoons 2F_2S_{(g)}}$, $\mathbf{K_{eq} = 9.1 \times 10^{-2}}$.
   Initially, a certain amount of difluorine monosulphide gas in added to a closed a system. When the system reaches equilibrium, the $[F_2]$ is 0.77M. What was the initial $[F_2S]$?

F7: Equilibrium Stoichiometry – As a reversible reaction reaches equilibrium. Calculate the equilibrium concentrations of all species given the value of Keq and the initial concentrations. (Part III)

1) The K_{eq} is 4 for the following reaction: $\mathbf{2HF_{(g)} \rightleftharpoons H_{2(g)} + F_{2(g)}}$. Initially, 5.0 moles of gaseous hydrofluoric acid are placed into a 2.0 L reaction vial. What are the [equilibrium] for all species?

F8: Determine whether a system is at equilibrium, and if not, in which direction it will shift to reach equilibrium when given a set of concentrations for reactants and products.

1) Using the following reversible reaction: $\mathbf{4NH_{3(g)} + 5O_{2(g)} \rightleftharpoons 4NO_{(g)} + 6H_2O_{(l)}}$. In a 2.0L container: 4.0 mol of ammonia, 5.0 mol of oxygen, 6.0 mol of nitrogen monoxide and 7.0 mol of dihydrogen monoxide are added. If the equilibrium constant for the reaction is 0.50, is the system at equilibrium? If not, how will the system work itself out (which reaction will be favoured) as it approaches equilibrium (explain your answer).