Law of Mass Action and the Equilibrium Constant

1) Review the Law of Mass Action and the equilibrium constant expression.

2) Meaning of the equilibrium constant (large → mostly products at equibrium, small → mostly reactants at equilibrium).

3) Algebraic consequences of the form of the equilibrium constant expression.
    a. reverse reaction has reciprocal of the equilibrium constant.
    b. multiplying reaction by a constant → original K is raised to that constant to get new K.
    c. adding two reactions → new K is product of Ks of added reactions.

4) Measuring an equilibrium constant: Let a system evolve to equilibrium, measure concentrations, then include these concentrations in the equilibrium constant expression to get K. (Next week's lab.)

5) Decide whether a system is at equilibrium: Let Q be the reaction quotient: the ratio of product concentrations raised to their stoichiometric coefficients divided by the reactant concentrations raised to their stoichiometric coefficients **at any time whether the system is at equilibrium or not.**

   So for the generic reaction aA + bB → cC + dD we define $Q = [C]^c[D]^d/[A]^a[B]^b$ where the molarities of substances A, B, C, and D are measured at any time, equilibrium or not. Then:
    a. if Q = K, the system is at equilibrium.
    b. if Q < K, the system will evolve towards products until equilibrium is reached.
    c. if Q > K, the system will evolve towards reactants until equilibrium is reached.

6) Homogeneous vs heterogeneous equilibrium.

7) Why we can leave pure solids, pure liquids, and essentially pure solvents out of the equilibrium constant expression.

8) Relationship between Kc and Kp for strictly gaseous reactions or reactions which have only gases in the equilibrium constant expression. $K_p = K_c(RT)^{\Delta n}$.

9) LeChatlier's Principle.

10) How to use the measured equilibrium constant to determine extent of reaction and final concentrations.

TABLE 13.2 Equilibrium constants, K_c, for various reactions

Reaction	Temperature, K	K_c
$H_2(g) + Cl_2(g) \rightleftharpoons 2\,HCl(g)$	300	4.0×10^{31}
	500	4.0×10^{18}
	1000	5.1×10^{8}
$H_2(g) + Br_2(g) \rightleftharpoons 2\,HBr(g)$	300	1.9×10^{17}
	500	1.3×10^{10}
	1000	3.8×10^{4}
$H_2(g) + I_2(g) \rightleftharpoons 2\,HI(g)$	298	794
	500	160
	700	54
$2\,BrCl(g) \rightleftharpoons Br_2(g) + Cl_2(g)$	300	377
	500	32
	1000	5
$2\,HD(g) \rightleftharpoons H_2(g) + D_2(g)$	100	0.52
	500	0.28
	1000	0.26
$F_2(g) \rightleftharpoons 2\,F(g)$	500	7.3×10^{-13}
	1000	1.2×10^{-4}
	1200	2.7×10^{-3}
$Cl_2(g) \rightleftharpoons 2\,Cl(g)$	1000	1.2×10^{-7}
	1200	1.7×10^{-5}
$Br_2(g) \rightleftharpoons 2\,Br(g)$	1000	4.1×10^{-7}
	1200	1.7×10^{-5}
$I_2(g) \rightleftharpoons 2\,I(g)$	800	3.1×10^{-5}
	1000	3.1×10^{-3}
	1200	6.8×10^{-2}