

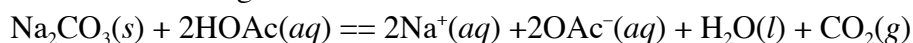
CHEM1011 WORKSHEET A

SAMPLE EXAM QUESTIONS

EQUILIBRIUM

Question 1.

(a) Consider the following reaction:



(i) Write an equilibrium constant expression.

$$K = \frac{[\text{Na}^+]^2 [\text{OAc}^-]^2 [\text{CO}_2]}{[\text{HOAc}]^2}$$

(ii) What would be the effect on the position of equilibrium and the equilibrium constant of the following changes:

- adding extra acetic acid (HOAc)

adding more reactant, so reaction to more product, K_c unchanged

- increasing the carbon dioxide pressure

adding more product, so reaction to more reactants, K_c unchanged

- doubling the volume of the solution by adding water at constant carbon dioxide pressure

K_c and p_{CO_2} remain unchanged;

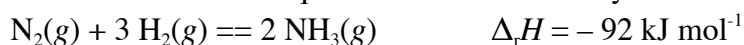
doubling the volume halves all solution concentrations, therefore:

$$Q_c = \frac{[\text{Na}^+]^2 [\text{OAc}^-]^2 [\text{CO}_2]}{[\text{HOAc}]^2} \cdot \left(\frac{1}{2} \right)^2 \left(\frac{1}{2} \right)^2 (1) / \left(\frac{1}{2} \right)^2 = 0.25 K_c.$$

$Q < K$, so reaction occurs to give more products

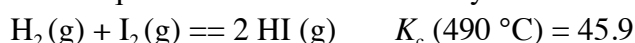
Question 2.

(a) Suggest four ways that the equilibrium concentration of ammonia can be increased in a reaction vessel in which the equilibrium is described by:

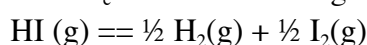


- adding N_2
- adding H_2
- decreasing vessel size
- removing heat (since exothermic; heat given out by the reaction)

(b) Given the equilibrium constant for the system



(i) Calculate K_c' for the following reaction:



Reverse equilibrium reaction: $K' = 1/K$
Multiply equilibrium reaction by n : $K'' = K^n$

$$K_c' = (K_c)^{-1/2} = (45.9)^{-1/2} = 0.148$$

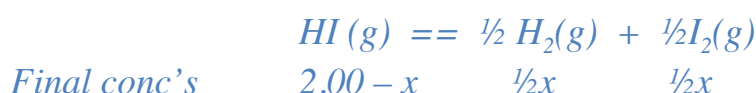
(ii) Write an expression for K_p' for the reaction given immediately (above in part (i)).

$$K_p = \frac{p(\text{H}_2)^{1/2} p(\text{I}_2)^{1/2}}{p(\text{HI})} = K_c' \left(\frac{RT}{p^\circ} \right)^{\Delta n_{\text{gas}}}$$

(iii) Calculate K_p' for this reaction.

$$\Delta n^{\text{gas}} = \left(\frac{1}{2} + \frac{1}{2} \right) - 1 = 0,$$
$$\text{so } K_p' = K_c' = 0.148$$

(iv) 2.00 mol of HI is introduced into a 1.0 L flask at 490 °C. What will be the final concentrations in the flask at equilibrium?



$$\text{so } K_c' = (\frac{1}{2}x)^{1/2}(\frac{1}{2}x)^{1/2}/(2.00 - x) = 0.148$$

$$\text{rearrange } (\frac{1}{2}x) = 0.148 \times (2.00 - x)$$

$$x = (2.00 \times 0.148)/(0.5 + 0.148) = 0.457 \text{ mol L}^{-1}$$

$$\text{so } [\text{H}_2] = [\text{I}_2] = \frac{1}{2}x = 0.23 \text{ mol L}^{-1}$$

$$\text{and } [\text{HI}] = 2.00 - 0.46 = 1.54 \text{ mol L}^{-1}$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$