

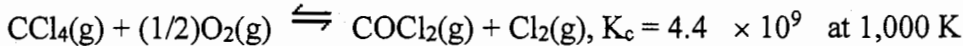
Show all work to receive credit.  $R = 8.314 \text{ J/(mol K)}$   $K_p = K_c(RT)^{\Delta n}$   $E = mc^2$

$R = 0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}$

1. (3 Pts) Write the equilibrium expression,  $K_c$ , for the following chemical reaction.  
 $\text{Sn}^{2+}(\text{aq}) + \frac{1}{2} \text{O}_2(\text{g}) + 3\text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{SnO}_2(\text{s}) + 2\text{H}_3\text{O}^+(\text{aq})$

$$K_c = \frac{[\text{H}_3\text{O}^+]^2}{[\text{Sn}^{2+}][\text{O}_2]^{1/2}}$$

2. (5 Pts) Carbon tetrachloride reacts at high temperatures with oxygen to produce two toxic gases, phosgene and chlorine.



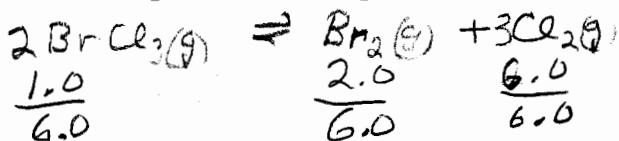
Calculate  $K_c$  for the reaction  $2\text{CCl}_4(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{COCl}_2(\text{g}) + 2\text{Cl}_2(\text{g})$ .

note 2<sup>nd</sup> reaction is doubled, so  $K$  is squared

$$(4.4 \times 10^9)^2 = 1.9 \times 10^{19}$$

3. (4 Pts) What is the value of the equilibrium constant,  $K_c$ , for the reaction:

$2\text{BrCl}_3(\text{g}) \rightleftharpoons \text{Br}_2(\text{g}) + 3\text{Cl}_2(\text{g})$  If an equilibrium mixture was found to contain 1.0 mol  $\text{BrCl}_3$ , 2.0 mol  $\text{Br}_2$  and 6.0 mol  $\text{Cl}_2$  in a 6.0 L vessel.



$$K_c = \frac{\left[\frac{2.0}{6.0}\right]\left[\frac{6.0}{6.0}\right]^3}{\left[\frac{1.0}{6.0}\right]^2}$$

$$K_c = 12$$

4. (3 Pts) Phosgene,  $\text{COCl}_2$ , a poisonous gas, decomposes according to the equation

$\text{COCl}_2(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + \text{Cl}_2(\text{g})$ . Calculate  $K_p$  for this reaction if  $K_c = 0.083$  at  $900^\circ\text{C}$ .

$$K_p = K_c (RT)^{\Delta n}$$

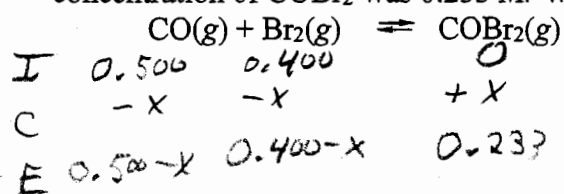
$$= 0.083 (0.0821 \cdot 1173)$$

$$= 8.0$$

$1 \leftarrow \Delta n = 1$

More questions on back.

5. (5 Pts) A mixture 0.500 mole of carbon monoxide and 0.400 mole of bromine was placed into a rigid 1.00-L container and the system was allowed to come to equilibrium. The equilibrium concentration of  $\text{COBr}_2$  was 0.233 M. What is the value of  $K_c$  for this reaction?



$$K_c = \frac{[\text{COBr}_2]}{[\text{CO}][\text{Br}_2]}$$

$$K_c = \frac{[0.233]}{[0.267][0.167]}$$

$$K_c = \frac{[0.233]}{[0.267][0.167]}$$

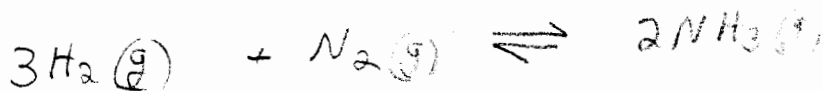
Since  $x = 0.233$

$$0.500 - 0.233 = 0.267$$

$$0.400 - 0.233 = 0.167$$

$$K_c = 5.23$$

6. (5 Pts) For the nitrogen fixation reaction  $3\text{H}_2\text{(g)} + \text{N}_2\text{(g)} \rightleftharpoons 2\text{NH}_3\text{(g)}$ ,  $K_c = 6.0 \times 10^{-2}$  at  $500^\circ\text{C}$ . If 0.250 M  $\text{H}_2$  and 0.050 M  $\text{NH}_3$  are present at equilibrium, what is the equilibrium concentration of  $\text{N}_2$ ?



I  
C  
E

$$0.250$$

?

$$0.050$$

$$K_c = \frac{[\text{NH}_3]^2}{[\text{H}_2]^3 [\text{N}_2]}$$

$$6.0 \times 10^{-2} = \frac{[0.050]^2}{[0.250]^3 [\text{N}_2]}$$

$$[\text{N}_2] = 2.7$$