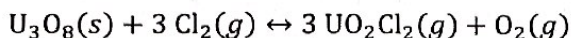


## AP Unit 6 Quiz Free Response Practice #1 [2007 #1, 6 points, modified]

1. A sample of solid  $\text{U}_3\text{O}_8$  is placed in a rigid 1.500 L flask. Chlorine gas,  $\text{Cl}_2(\text{g})$ , is added, and the flask is heated to  $862^\circ\text{C}$ . The equation for the reaction that takes place and the equilibrium constant expression for the reaction are given below.



When the system is at equilibrium, the partial pressure of  $\text{Cl}_2(\text{g})$  is 1.007 atm, the partial pressure of  $\text{UO}_2\text{Cl}_2(\text{g})$  is  $9.734 \times 10^{-4}$  atm, and the partial pressure of  $\text{O}_2(\text{g})$  is  $3.245 \times 10^{-4}$  atm.

- a. Write the equilibrium constant expression,  $K_p$ , for this reaction and calculate the value of  $K_p$  for the system at  $862^\circ\text{C}$ . [2 points]

$$K_p = \frac{(P_{\text{UO}_2\text{Cl}_2})^3 (P_{\text{O}_2})}{(P_{\text{Cl}_2})^3} = \frac{(9.734 \times 10^{-4})^3 (3.245 \times 10^{-4})}{(1.007)^3} = \boxed{2.931 \times 10^{-13}}$$

- b. Calculate the concentration of  $\text{Cl}_2(\text{g})$  at equilibrium. [1 point]

$$PV = nRT \Rightarrow \frac{n}{V} = \frac{P}{RT} = \frac{1.007 \text{ atm}}{(0.08206 \text{ L}\cdot\text{atm}) \cdot (862 + 273 \text{ K})} = \boxed{0.01081 \text{ M}}$$

could also just solve for n + use moles and volume to calculate [ ]

- c. Calculate the Gibb's free-energy change,  $\Delta G^\circ$ , for the reaction at  $862^\circ\text{C}$ . [1 point]

$$\Delta G = -RT \ln K = (-8.314 \frac{\text{J}}{\text{mol}\cdot\text{K}})(1135 \text{ K}) \ln(2.931 \times 10^{-13})$$

$$= \boxed{272,300 \frac{\text{J}}{\text{mol rxn}} \text{ or } 272.3 \frac{\text{kJ}}{\text{mol rxn}}}$$

- d. After a certain period of time, 1.000 mole of  $\text{O}_2(\text{g})$  is added to the mixture in the flask. Does the mass of  $\text{U}_3\text{O}_8(\text{s})$  in the flask increase, decrease, or remain the same? Justify your answer. [2 point]

The mass of  $\text{U}_3\text{O}_8(\text{s})$  will increase. Adding  $\text{O}_2(\text{g})$ , a product, will cause the rxn to shift left to re-establish equilibrium by using up some added  $\text{O}_2(\text{g})$ , producing more  $\text{U}_3\text{O}_8(\text{s})$ .

## AP Unit 6 Quiz Free Response Practice #2 [Laying the Foundation, 9 points]

2. When 3.29 moles of nitrogen gas,  $N_2$ , and 2.95 moles of hydrogen gas,  $H_2$ , are placed in a 5.00 L evacuated container at 773 K, ammonia gas,  $NH_3$ , is formed according to this equation:  $N_2(g) + 3 H_2(g) \leftrightarrow 2 NH_3(g)$
- When equilibrium is established, 0.565 mole of  $NH_3(g)$  is present in the flask.

a. Write the expression for the equilibrium constant,  $K_c$ , for this reaction. [1 point]

$$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

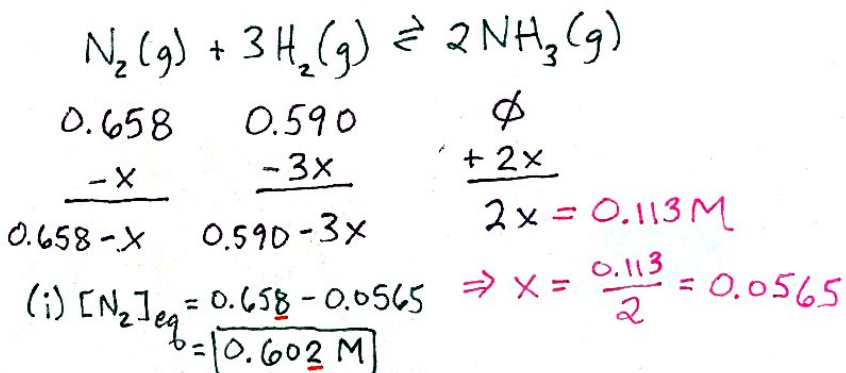
b. Calculate the equilibrium concentrations, in  $\text{mol L}^{-1}$ , of the following gases in the container at 773 K.

i.  $N_2(g)$  [1 point]

$$[N_2]_i = \frac{3.29 \text{ mol}}{5.00 \text{ L}} = 0.658 \text{ M}$$

$$[H_2]_i = \frac{2.95 \text{ mol}}{5.00 \text{ L}} = 0.590 \text{ M}$$

$$[NH_3]_{eq} = \frac{0.565 \text{ mol}}{5.00 \text{ L}} = \boxed{0.113 \text{ M}}$$



ii)  $[H_2]_{eq} = 0.590 - 3(0.0565)$   
 $= \boxed{0.421 \text{ M}}$

c. Calculate the value of the equilibrium constant,  $K_c$ , at 773 K. [1 point]

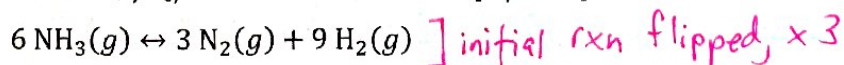
$$K_c = \frac{(0.113)^2}{(0.602)(0.421)^3} = \boxed{0.284}$$

d. When the same reaction is carried out at  $298 \text{ K}$ , the number of moles of  $NH_3$  present at equilibrium is much larger than 0.565 mole. Is the forward reaction endothermic or exothermic? Justify your answer. [1 point]

Exothermic, because decreasing temp. (from 773 K to 298 K) increases [products] (since moles of  $NH_3$  increased). Since the system will shift towards heat when

$\downarrow T$ , heat must be a product of this rxn.

e. Calculate the value of the equilibrium constant,  $K_c$ , for the reaction below. [1 points]



$$K' = \frac{1}{K^3} = \frac{1}{(0.284)^3} = \boxed{43.7}$$