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

1. A sample of solid U_3O_8 is placed in a rigid 1.500 L flask. Chlorine gas, $Cl_2(g)$, is added, and the flask is heated to 862°C. The equation for the reaction that takes place and the equilibrium constant expression for the reaction are given below.

$$U_3O_8(s) + 3\,Cl_2(g) \leftrightarrow 3\,UO_2Cl_2(g) + O_2(g)$$

When the system is at equilibrium, the partial pressure of $Cl_2(g)$ is 1.007 atm, the partial pressure of $UO_2Cl_2(g)$ is 9.734×10^{-4} atm, and the partial pressure of $O_2(g)$ is 3.245×10^{-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°C. [2 points]

$$K_p = \frac{(P_{UO_2Cl_2})^3 (P_{O_2})}{(P_{Cl_2})^3} = \frac{(9.734E-4)^3(3.245E-4)}{(1.007)^3} = \boxed{2.931 \times 10^{-13}}$$

b. Calculate the concentration of $Cl_2(g)$ at equilibrium. [1 point]

$$PV = nRT \Rightarrow \frac{n}{V} = \frac{P}{RT} = \frac{1.007 \text{ atm}}{(0.08206)(1135\text{ K})} = \boxed{0.01081\text{ M}}$$

$= \frac{mol}{L}$:)

862 + 273

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

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

$$\Delta G = -RT\ln K = \left(-8.314 \tfrac{J}{mol\cdot K}\right)(1135\text{ K})\ln(2.931E-13)$$

$$= \boxed{272{,}300 \tfrac{J}{mol_{rxn}} \text{ or } 272.3 \tfrac{kJ}{mol_{rxn}}}$$

d. After a certain period of time, 1.000 mole of $O_2(g)$ is added to the mixture in the flask. Does the mass of $U_3O_8(s)$ in the flask increase, decrease, or remain the same? Justify your answer. [2 point]

The mass of $U_3O_8(s)$ will increase. Adding $O_2(g)$, a product, will cause the rxn to shift left to re-establish equilibrium by using up some added $O_2(g)$, producing more $U_3O_8(s)$.

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 mol L^{-1}, of the following gases in the container at 773 K.

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

ii. $H_2(g)$ [1 point]

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

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

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

$N_2(g) + 3H_2(g) \rightleftarrows 2NH_3(g)$

$N_2(g)$	$3H_2(g)$	$2NH_3(g)$
0.658	0.590	∅
−x	−3x	+2x
0.658 − x	0.590 − 3x	2x = 0.113 M

$\Rightarrow x = \frac{0.113}{2} = 0.0565$

(i) $[N_2]_{eq} = 0.658 - 0.0565 = \boxed{0.602\text{ M}}$

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 K (< 773 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 773K to 298K) increases [products] (since moles of NH_3 increased). Since the system will shift towards heat when ↓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]

$6\,NH_3(g) \leftrightarrow 3\,N_2(g) + 9\,H_2(g)$] initial rxn flipped, ×3

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