General Chemistry II
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Examination #3

Name _____

(4) 1. A system, 1 $A_2B(s) \rightleftharpoons 2\ A(g) + 1\ B(g)$, already at equilibrium is perturbed at a given temperature. If the new equilibrium concentration of A(g) at the given temperature is one half its original equilibrium value, then the new equilibrium concentration of B(g) will be:

a) one quarter of its original equilibrium value
b) four times its original equilibrium value
c) one half of its original equilibrium value
d) twice its original equilibrium value

Questions (2)-(4) pertain to the equilibrium reaction shown below:

$$2\ SO_3(g) \rightleftharpoons 2\ SO_2(g) + 1\ O_2(g) \quad \Delta H = +45\ kcal$$

(4) 2. Which one of the following sets of conditions would **maximize** <u>product</u> formation:

a) low temperature/low volume
b) low temperature/high volume
c) high temperature/low volume
d) high temperature/high volume

(4) 3. In the above equilibrium reaction, the number of moles of $SO_3(g)$ will **increase** if:

a) the temperature of the system is increased at constant volume
b) $O_2(g)$ is removed from the system at constant temperature and volume
c) the pressure of the system is increased by adding Ar gas
d) the volume of the system is increased at constant temperature
e) None of the above choices is correct

(4) 4. The numerical value of K_C for the above equilibrium reaction will **increase** if:

a) the temperature of the system is increased at constant volume
b) the volume of the system is increased at constant temperature
c) $O_2(g)$ is added to the system at constant temperature and volume
d) $SO_3(g)$ is added to the system at constant temperature and volume
e) None of the above choices is correct

(4) 5. For the system, 1 A(g) + 1 B(g) $\rightleftharpoons$ 1 C(g) + 1 D(g), $K_p = 10$
At equilibrium, it must **always** be true that:

a) $P_A P_B = P_C P_D$ b) $P_A = P_C$

c) $P_A P_B = 0.10 P_C P_D$ d) $P_A P_B = 10 P_C P_D$

e) None of the above choices is correct

Questions (6)-(8) pertain to the equilibrium reaction and data shown below:

$$2\ NO(g) + 1\ Cl_2(g) \rightleftharpoons 2\ NOCl(g)$$

At a given temperature, 0.30 moles of NO(g), 0.20 moles of $Cl_2(g)$, and 0.50 moles of NOCl(g) are introduced into a 25 liter reaction flask. When equilibrium is established, 0.60 moles of NOCl(g) are present.

(4) 6. The equilibrium concentration of $Cl_2(g)$ is:

a) 0.006M b) 0.008M c) 0.100M d) 0.150M e) 0.200M

(4) 7. The equilibrium concentration of NO(g) is:

a) 0.006M b) 0.008M c) 0.012M d) 0.060M e) 0.100M

(4) 8. The numerical value of K_c for the above equilibrium is:

a) 0.202 b) 60 c) 900 d) 1500 e) 2000

9. For the equilibrium reaction $2\ NO_2(g) \rightleftharpoons 1\ N_2O_4(g)$, $NO_2(g)$ is a reddish-brown color, whereas $N_2O_4(g)$ is colorless. At 0°C, an equilibrium mixture of the two gases is almost colorless, whereas, at 100°C, the equilibrium mixture is reddish-brown in appearance.

(4) a) Based on the above data, at which temperature, (0°C, 100°C), is product formation favored?

(4) b) Based on the above data, product formation is an (endothermic, exothermic) reaction.

(4) c) If, at 0°C, the volume of the system is **increased** significantly, the appearance of the reaction mixture will (lighten, darken).

(4) 10. Consider the following equilibrium reaction:

$$2\,A(g) + 1\,B(g) \rightleftharpoons 3\,C(g) + 1\,D(g)$$

If **equal** numbers of moles of A(g) and B(g) are added to an empty reaction vessel at a given temperature, then the following must **always** be true for the above system when equilibrium is achieved:

a) $P_B = P_D$ b) $P_C > P_A$ c) $P_B < P_A$ d) $P_B > P_A$

e) None of the above must **always** be true for the above system at equilibrium

(4) 11. Consider the following equilibrium reaction:

$$1\,N_2O_4(g) \rightleftharpoons 2\,NO_2(g)$$

At 30°C, an equilibrium mixture of $N_2O_4(g)$ and $NO_2(g)$ exerts a total pressure of 0.750 atm. If the partial pressure of $N_2O_4(g)$ is 0.500 atm, then K_p for the above equilibrium is:

a) 1.50 b) 1.00 c) 0.750 d) 0.500 e) 0.125

(4) 12. At a given temperature, for the equilibrium reaction

$$1\,NH_3(g) + 1\,H_2S(g) \rightleftharpoons 1\,NH_4SH(s), \quad K_c = 400$$

If, initially, one mole of $NH_3(g)$ and one mole of $H_2S(g)$ are introduced into a 10.0 liter evacuated reaction vessel, how many moles of $NH_4SH(s)$ will be present when equilibrium is established?
[Hint: 1) Determine how many moles of $NH_3(g)$ and $H_2S(g)$ are present at equilibrium, and 2) determine the number of moles of each that must have reacted to produce $NH_4SH(s)$]

a) 1.00 mole b) 0.50 mole c) 0.40 mole d) 0.10 mole e) 0.05 mole

(3) 13. Consider the following equilibrium reaction at a given temperature:

$$1\,I_2(CCl_4) \rightleftharpoons 1\,I_2(H_2O) \qquad K_c = 0.012$$

Relative to its solubility in CCl_4, I_2 is (more, less) soluble in water.

(4) 14. Consider the following equilibrium reaction:

$$8\ H_2S(g) \rightleftharpoons 8\ H_2(g) + 1\ S_8(s)$$

For the above equilibrium, it must **always** be true that:

a) $K_p = K_c$ b) $K_p > K_c$ c) $K_p < K_c$

d) The relative numerical values of the equilibrium constant will depend on P_{total} for the system

e) None of the above choices is correct

(4) 15. If, at 25°C, $K_c = 2.50$ for $2\ A(g) + 1\ B(g) \rightleftharpoons 3\ D(g)$, then, at 25°C, K_c for $3\ D(g) \rightleftharpoons 2\ A(g) + 1\ B(g)$ will be:

a) -2.50 b) 2.50 c) 0.25 d) -0.40 e) 0.40

(6) 16. When a sample of $NH_4OCONH_2(s)$ is introduced into an empty reaction vessel at 25°C, the following equilibrium system is established:

$$1\ NH_4OCONH_2(s) \rightleftharpoons 2\ NH_3(g) + 1\ CO_2(g) \qquad K_p = 2.90\times10^{-3}$$

Determine the **total pressure** of the equilibrium system shown above. Show all work in the space provided.

(6) 17. Consider the following equilibrium reaction:

$$1\ N_2(g) + 1\ O_2(g) \rightleftharpoons 2\ NO(g) \qquad K_c = 4.17\times10^{-31} \text{ at } 25^\circ C$$

If 1.0 mole $N_2(g)$ and 1.0 mole $O_2(g)$ are introduced into an empty 20 liter reaction vessel, determine the concentration (in M) of all species present at equilibrium. Show all work in the space provided.

(4) 18. Consider the following equilibrium reaction at a given temperature:

$$2\,NO_2(g) + 2\,N_2H_4(g) \rightleftharpoons 3\,N_2(g) + 4\,H_2O(g) \qquad K_c = 8.50$$

Initially, 0.10 moles of $NO_2(g)$, 2.00 moles of $N_2H_4(g)$, 4.00 moles of $N_2(g)$, and 1.00 mole of $H_2O(g)$ are introduced into a 2.0 liter vessel. The system:

a) is at equilibrium initially b) will shift to create more products
c) will shift to create more reactants
d) From the data given, one cannot tell what the system will do

19. Given the following equilibria at 25°C:

$$1N_2(g) + 3H_2(g) \rightleftharpoons 2\,NH_3(g) \qquad K_p = 6.80\times10^{5}$$

$$1NH_4Cl(s) \rightleftharpoons 1NH_3(g) + 1\,HCl(g) \qquad K_p = 7.31\times10^{-17}$$

$$1\,H_2(g) + 1\,Cl_2(g) \rightleftharpoons 2\,HCl(g) \qquad K_p = 2.52\times10^{33}$$

(9) a) Determine K_p for the following equilibrium at 25°C:

$$\tfrac{1}{2}N_2(g) + 2\,H_2(g) + \tfrac{1}{2}\,Cl_2(g) \rightleftharpoons 1NH_4Cl(s)$$

Show all work in the space provided.

(4) b) Based on the K_p value obtained in Part (a), determine the corresponding K_c value. Show all work in the space provided.

(4) c) Determine ΔG°, in kJ, for the equilibrium reaction shown in Part (a) based on its calculated K_p value. Show all work in the space provided.