**Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Equilibrium Quiz**

1)At equilibrium, \_\_\_\_\_\_\_\_\_\_.

|  |  |
| --- | --- |
| A) | all chemical reactions have ceased |
| B) | the rates of the forward and reverse reactions are equal |
| C) | the rate constants of the forward and reverse reactions are equal |
| D) | the value of the equilibrium constant is 1 |
| E) | the limiting reagent has been consumed |

2)Which one of the following will change the value of an equilibrium constant?

|  |  |
| --- | --- |
| A) | changing temperature |
| B) | adding other substances that do not react with any of the species involved in the equilibrium |
| C) | varying the initial concentrations of reactants |
| D) | varying the initial concentrations of products |
| E) | changing the volume of the reaction vessel |

3)Which of the following expressions is the correct equilibrium-constant expression for the following reaction?

CO2 (g) + 2H2 (g)  CH3OH (g)

|  |  |
| --- | --- |
| A) |  |
| B) |  |
| C) |  |
| D) |  |
| E) |  |

4)The equilibrium constant for reaction 1 is K. The equilibrium constant for reaction 2 is \_\_\_\_\_\_\_\_\_\_.

(1) SO2 (g) + (1/2) O2 (g)  SO3 (g)

(2) 2SO3 (g)  2SO2 (g) + O2 (g)

|  |  |
| --- | --- |
| A) | K2 |
| B) | 2K |
| C) | 1/2K |
| D) | 1/K2 |
| E) | -K2 |

5)Given the following reaction at equilibrium, if Kc = 1.90 x 1019 at 25.0°C, Kp = \_\_\_\_\_\_\_\_\_\_.

H2 (g) + Br2 (g)  2 HBr (g)

|  |  |
| --- | --- |
| A) | 5.26 x 10-20 |
| B) | 1.56 x 104 |
| C) | 6.44 x 105 |
| D) | 1.90 x 1019 |
| E) | none of the above |

6)The equilibrium expression for Kp for the reaction below is \_\_\_\_\_\_\_\_\_\_.

2O3 (g)  3O2 (g)

|  |  |
| --- | --- |
| A) |  |
| B) |  |
| C) |  |
| D) |  |
| E) |  |

7)Which of the following expressions is the correct equilibrium-constant expression for the reaction below?

CO2 (s) + H2O (l)  H+ (aq) + HCO3- (aq)

|  |  |
| --- | --- |
| A) | [H+][HCO3-] / [CO2] |
| B) | [CO2] / [H+][HCO3-] |
| C) | [H+][HCO3-] / [CO2][H2O] |
| D) | [CO2][H2O] / [H+][HCO3-] |
| E) | [H+][HCO3-] |

8)The equilibrium constant for the gas phase reaction

2SO2 (g) + O2 (g)  2SO3 (g)

is Keq = 2.80 x 102 at 999 K. At equilibrium, \_\_\_\_\_\_\_\_\_\_.

|  |  |
| --- | --- |
| A) | products predominate |
| B) | reactants predominate |
| C) | roughly equal amounts of products and reactants are present |
| D) | only products are present |
| E) | only reactants are present |

9)Consider the following equilibrium.

2SO2 (g) + O2 (g)  2SO3 (g)

The equilibrium cannot be established when \_\_\_\_\_\_\_\_\_\_ is/are placed in a 1.0-L container.

|  |  |
| --- | --- |
| A) | 0.25 mol SO2 (g) and 0.25 mol O2 (g) |
| B) | 0.75 mol SO2 (g) |
| C) | 0.25 mol of SO2 (g) and 0.25 mol of SO3 (g) |
| D) | 0.50 mol O2 (g) and 0.50 mol SO3 (g) |
| E) | 1.0 mol SO3 (g) |

10)At 400 K, the equilibrium constant for the reaction

Br2 (g) + Cl2 (g)  2BrCl (g)

is Kp = 7.0. A closed vessel at 400 K is charged with 1.00 atm of Br2 (g), 1.00 atm of Cl2 (g), and 2.00 atm of BrCl (g). Use Q to determine which of the statements below is true.

|  |  |
| --- | --- |
| A) | The equilibrium partial pressures of Br2, Cl2, and BrCl will be the same as the initial values. |
| B) | The equilibrium partial pressure of Br2 will be greater than 1.00 atm. |
| C) | At equilibrium, the total pressure in the vessel will be less than the initial total pressure. |
| D) | The equilibrium partial pressure of BrCl (g) will be greater than 2.00 atm. |
| E) | The reaction will go to completion since there are equal amounts of Br2 and Cl2. |

11) How is the reaction quotient used to determine whether a system is at equilibrium?

|  |  |
| --- | --- |
| A) | The reaction quotient must be satisfied for equilibrium to be achieved. |
| B) | At equilibrium, the reaction quotient is undefined. |
| C) | The reaction is at equilibrium when Q < Keq. |
| D) | The reaction is at equilibrium when Q > Keq. |
| E) | The reaction is at equilibrium when Q = Keq. |

12) Of the following equilibria, only \_\_\_\_\_\_\_\_\_\_ will shift to the left in response to a decrease in volume.

|  |  |
| --- | --- |
| A) | H2 (g) + Cl2 (g)  2 HCl (g) |
| B) | 2 SO3 (g)  2 SO2 (g) + O2 (g) |
| C) | N2 (g) + 3 H2 (g)  2 NH3 (g) |
| D) | 4 Fe (s) + 3 O2 (g)  2 Fe2O3 (s) |
| E) | 2HI (g)  H2 (g) + I2 (g) |

13) The reaction below is exothermic:

2SO2 (g) + O2 (g)  2SO3 (g)

Le Châtelier's Principle predicts that \_\_\_\_\_\_\_\_\_\_ will result in an increase in the number of moles of SO3 (g) in the reaction container.

|  |  |
| --- | --- |
| A) | increasing the pressure |
| B) | decreasing the pressure |
| C) | increasing the temperature |
| D) | removing some oxygen |
| E) | increasing the volume of the container |

14) For the endothermic reaction

CaCO3 (s)  CaO (s) + CO2 (g)

Le Châtelier's principle predicts that \_\_\_\_\_\_\_\_\_\_ will result in an increase in the number of moles of CO2.

|  |  |
| --- | --- |
| A) | increasing the temperature |
| B) | decreasing the temperature |
| C) | increasing the pressure |
| D) | removing some of the CaCO3 (s) |
| E) | none of the above |

15) Consider the following reaction at equilibrium:

2CO2 (g)  2CO (g) + O2 (g) H° = -514 kJ

Le Châtelier's principle predicts that an increase in temperature will \_\_\_\_\_\_\_\_\_\_.

|  |  |
| --- | --- |
| A) | increase the partial pressure of O2 (g) |
| B) | decrease the partial pressure of CO2 (g) |
| C) | decrease the value of the equilibrium constant |
| D) | increase the value of the equilibrium constant |
| E) | increase the partial pressure of CO |

16) Consider the following reaction at equilibrium:

C (s) + H2O (g)  CO (g) + H2 (g)

Which of the following conditions will increase the partial pressure of CO?

|  |  |
| --- | --- |
| A) | decreasing the partial pressure of H2O (g) |
| B) | removing H2O (g) from the system |
| C) | decreasing the volume of the reaction vessel |
| D) | decreasing the pressure in the reaction vessel |
| E) | increasing the amount of carbon in the system |

17)The effect of a catalyst on an equilibrium is to \_\_\_\_\_\_\_\_\_\_.

|  |  |
| --- | --- |
| A) | increase the rate of the forward reaction only |
| B) | increase the equilibrium constant so that products are favored |
| C) | slow the reverse reaction only |
| D) | increase the rate at which equilibrium is achieved without changing the composition of the equilibrium mixture |
| E) | shift the equilibrium to the right |

18)Dinitrogen tetroxide partially decomposes according to the following equilibrium:

N2O4 (g)  2NO2 (g)

A 1.000-L flask is charged with 3.00 x 10-2 mol of N2O4. At equilibrium, 2.36 x 10-2 mol of N2O4 remains. Keq for this reaction is \_\_\_\_\_\_\_\_\_\_.

|  |  |
| --- | --- |
| A) | 0.723 |
| B) | 0.391 |
| C) | 0.212 |
| D) | 6.94 x 10-3 |
| E) | 1.92 x 10-4 |

19)Nitrosyl bromide decomposes according to the following equation.

2NOBr (g)  2NO (g) + Br2 (g)

A sample of NOBr (0.64 mol) was placed in a 1.00-L flask containing no NO or Br2. At equilibrium the flask contained 0.36 mol of NOBr. How many moles of NO and Br2, respectively, are in the flask at equilibrium?

|  |  |
| --- | --- |
| A) | .28,.28 |
| B) | .36,.18 |
| C) | .28,.14 |
| D) | .14,.23 |
| E) | .36,.36  20) Consider the reaction: 2SO2 + O2  2SO3 + heat. Under which conditions is SO3 most stable?  A) high pressure and high temperature  B) high pressure and low temperature  C) low pressure and high temperature  D) low pressure and low temperature  21) The equilibrium constant for the gaseous reaction **C** + **D**  **E** + 2**F** is 3.0 at 50 °C. In a 2.0 L flask at 50 °C are placed 1.0 mol of **C**, 1.0 mol of **D**, 1.0 mol of **E**, and 3.0 mol of **F**. Initially, the reaction will  A) proceed at equal rates in both directions.  B) proceed more rapidly to form **E** and **F**.  C)proceed more rapidly to form **C** and **D**.  D) not occur in either direction.  22) In the reaction: heat + CaSO3*(s)*  CaO*(s)* + SO2*(g)* which change will cause an increase in the pressure of SO2*(g)* when equilibrium is re-established?  A) increasing the reaction temperature  B) decreasing the volume of the container  C) adding some more CaSO3  D) removing some of the CaO*(s)*  23) Which factor would cause a change in the equilibrium constant, *K*c, for this reaction?  2NOCl*(g)*  2NO*(g)* + Cl2*(g)*  A) adding NO*(g)*  B)decreasing the volume of the reaction vessel  C)cooling the system  D)adding an inert gas  24) When the reversible reaction N2 + O2  2NO has reached a state of equilibrium  A) no further reaction occurs.  B) the total moles of products must equal the remaining moles of reactant.  C) the addition of a catalyst will cause formation of more NO.  D) the concentration of each substance in the system will be constant.  E) the product [N2] [O2] equals [NO]2.  25) The equilibrium constant *K*p for the conversion butane*(g)*  isobutane*(g)* is 2.54 at 25 °C. If butane at 1.00 atm is allowed to come to equilibrium, the partial pressure of isobutane in the equilibrium mixture will be  A)0.390 atm  B)1.65 atm  C)2.54 atm  D)0.720 atm  26) Into an empty vessel COCl2*(g)* is introduced at 1.0 atm pressure whereupon it dissociates until equilibrium is established:2COCl2*(g)*  C*(graphite)* + CO2*(g)* + 2Cl2*(g)*  If *x* represents the partial pressure of CO2*(g)* at equilibrium, what is the value of the equilibrium constant, *K*p?  A)  B)  C)  D)  27) Calculate *K*eq in terms of molar concentration for the reaction:  N2*(g)* + 3H2*(g)* 2NH3*(g)*  when the equilibrium concentration moles per liter are:  N2 = 0.02, H2 = 0.01, NH3 = 0.10.  A) 2 10–6  B) 5 103  C) 5 105  D)5 107  28) Consider the interrelated equilibria:  Cu2+*(aq)* + 4NH3*(aq)*  Cu(NH3)42+*(aq)*  NH3*(aq)* + H2O  NH4+*(aq)* + OH–*(aq)*  3OH–*(aq)* + Fe3+*(aq)*  Fe(OH)3*(s)*  Addition of more Fe3+ will  A) increase the amount of Cu2+  B) increase the amount of Cu(NH3)42+  C) decrease the amount of Cu2+  D) decrease the amount of NH4+ |

29) Equal volumes of 1 M BaCl2 and 1 M Na2SO4 are mixed. What effect will the addition of more Na2SO4 solution have on the concentration of Ba2+ remaining in solution?

A) no effect

B) increase the concentration of Ba2+ ions

C) decrease the concentration of Ba2+ ions

D) Ba2+ will remain the same concentration, but be ionized less.

E) There are no Ba2+ ions in solution, so the Na2SO4 has nothing with which to react.

## Short Answer

1. A 1.20-L flask contains an equilibrium mixture of 0.0168 mol of N2, 0.2064 mol of H2, and 0.0143 mol of NH3. Calculate the equilibrium constant, *K*c for the reaction

N2*(g)* + 3H2*(g)*  2NH3*(g)*

1. Explain why orange dichromate solutions (Cr2O7)-2 turn yellow (CrO4)-2 when sodium hydroxide is added. (3 points)

Cr2O7-2(aq) + H2O(l)  2CrO4-2 (aq) + H+(aq)

**From the 1995 exam**

5 points each

CO2*(g)* + H2*(g)*  H2O*(g)* + CO*(g)*

1. When H2*(g)* is mixed with CO2*(g)* at 2,000 K, equilibrium is achieved according to the equation above. In one experiment, the following equilibrium concentrations were measured.

[H2] = 0.20 mol/L

[CO2] = 0.30 mol/L

[H2O] = [CO] = 0.55 mol/L

1. Using the equilibrium concentrations given above, calculate the value of *Kc*, the equilibrium constant for the reaction.
2. Determine *Kp* in terms of *Kc* for this system.
3. When the system is cooled from 2,000 K to a lower temperature, 30.0 percent of the CO*(g)* is converted back to CO2*(g)*. Calculate the value of *Kc* at this lower temperature.
4. In a different experiment, 0.50 mole of H2*(g)* is mixed with 0.50 mole of CO2*(g)* in a 3.0-liter reaction vessel at 2,000 K. Calculate the equilibrium concentration, in moles per liter, of CO*(g)* at this temperature.

**From the 2008 Exam**

**5 points each**

C(*s*) + CO2(*g*)  2 CO(*g*)

Solid carbon and carbon dioxide gas at 1,160 K were placed in a rigid 2.00 L container, and the reaction

represented above occurred. As the reaction proceeded, the total pressure in the container was monitored.

When equilibrium was reached, there was still some C(*s*) remaining in the container. Results are recorded

in the table below.

|  |  |
| --- | --- |
| Time (hours) | Total Pressure of Gases in Container at 1,160 K(atm) |
| 0.0 | 5.00 |
| 2.0 | 6.26 |
| 4.0 | 7.09 |
| 6.0 | 7.75 |
| 8.0 | 8.37 |
| 10.0 | 8.37 |

1. Write the expression for the equilibrium constant, *Kp* , for the reaction.
2. Calculate the number of moles of CO2 originally placed in the container.
3. For the reaction mixture at equilibrium at 1,160 K, the partial pressure of the CO2(*g*) is 1.63 atm. Calculate the
   1. partial pressure of CO(*g*) and,
   2. the value of the equilibrium constant, *Kp* .
4. If a suitable solid catalyst were placed in the reaction vessel, would the final total pressure of the gases at equilibrium be greater than, less than, or equal to the final total pressure of the gases at equilibrium without the catalyst? Justify your answer. (Assume that the volume of the solid catalyst is negligible.)

In another experiment involving the same reaction, a rigid 2.00 L container initially contains 10.0 g of C(*s*) ,

plus CO(*g*) and CO2(*g*) , each at a partial pressure of 2.00 atm at 1,160 K.

1. Predict whether the partial pressure of CO2(*g*) will increase, decrease, or remain the same as this system approaches equilibrium. Justify your prediction with a calculation.