Chemistry 30 Equilibrium Mid-Unit Quiz Name: KEY

Write the letter of the correct answer on the line for each question.

___ 1. What would happen to the value of K_C for the reaction: $N_2O_4(g) \rightleftharpoons 2NO_2(g)$, if the pressure of the $N_2O_4(g)$ is doubled?

- pressure does not change the K_C value. The K_C value always depends on the temperature

a) K_C would not be affected.
b) K_C would be halved.
c) K_C would be doubled.
d) K_C would increase by a factor of 4.

___ 2. The equilibrium constant, K_C, for the reaction, $2H_2(g) + O_2(g) \leftrightarrow 2H_2O(g)$, is equal to 2×10^{81} at 25°C. This value suggests that:

a) this reaction favors the forward reaction slightly more than the reverse reaction.
b) this reaction favors the reverse reaction slightly more than the forward reaction.
c) this reaction virtually goes to completion with little reversal.
d) this reaction virtually does not proceed forward and largely favors the reactants.

The next two questions refer to the equation below which shows bromine dissolving in water. Assume that the reaction is at equilibrium.

$$\underset{\text{red}}{Br_2(aq)} + H_2O(l) \rightleftharpoons H^+(aq) + Br^-(aq) + \underset{\text{colourless}}{HBr(aq)}$$

$H^+(aq)$

___ 3. What observation would you expect if dilute acid such as hydrochloric acid were added to the system at equilibrium?

a) No observable change.
b) The solution would become colorless.
c) The solution would become red.
d) The solution would become green.

___ 4. Which one of the following would NOT cause the reaction to shift to the right?

a) Addition of Br^- ions to the system.
b) Decreasing the $[H^+]$.
c) Addition of Br_2.
d) Addition of H_2O.

NUMERICAL RESPONSE 1:
The concentration of $H_3O^+(aq)$ ions in a particular bottle of wine is 3.2×10^{-4} mol/L. The pH of this wine is: 3.49. (Record your three digit answer)

NUMERICAL RESPONSE 2:
If the concentration of $H_3O^+(aq)$ in a sulfuric acid solution is 1.2×10^{-5} mol/L, then the pOH of this solution is: 9.08. (Record your three digit answer)

pH = 4.9208
pOH = 14 - 4.9208

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___ 5. The equilibrium law expression for an industrial method of producing ethanol is:

$$K_C = \frac{[C_2H_5OH(g)]}{[C_2H_4(g)][H_2O(g)]}$$

Under certain conditions, the K_C= 300.0. At equilibrium, a 5000 L reaction vessel contains 115 mol of $C_2H_4(g)$ and 110 mol of $H_2O(g)$. The equilibrium concentration of the ethanol is:

0.023 mol/L

0.022 mol/L

a) 1.60×10^{-6} mol/L
b) 0.152 mol/L
c) 75.0 mol/L
d) 5.92×10^{5} mol/L

$300 = \frac{x}{(0.023)(0.022)}$

$x = 0.1518$

___ 6. For the equilibrium, $PCl_5(g) \leftrightarrow PCl_3(g) + Cl_2(g)$, the equilibrium constant at two temperatures is given below:

Temperature	Keq
227°C	2.24
486°C	33.3

right

According to this information, as the temperature of the system increases, the equilibrium shifts:

a) left and the reaction is exothermic
b) left and the reaction is endothermic
c) right and the reaction is exothermic
d) right and the reaction is endothermic

The next two questions refer to the following information.

When dilute hydrochloric acid is added to a solution of potassium chromate, a solution of potassium dichromate is produced. This is an example of a reversible reaction where there are no visible changes to the colour of the solution formed once equilibrium has been reached.

$$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l) + 42\ kJ$$

___ 7. The K_C expression for this reaction is:

a) $K_C = \frac{[Cr_2O_7^{2-}{}_{(aq)}]}{2[CrO_4^{2-}{}_{(aq)}]\ 2[H^+{}_{(aq)}]}$

b) $K_C = \frac{2[CrO_4^{2-}{}_{(aq)}]\ 2[H^+{}_{(aq)}]}{[Cr_2O_7^{2-}{}_{(aq)}]}$

c) $K_C = \frac{[Cr_2O_7^{2-}{}_{(aq)}]}{[CrO_4^{2-}{}_{(aq)}]^2\ [H^+{}_{(aq)}]^2}$

d) $K_C = \frac{[CrO_4^{2-}{}_{(aq)}]^2\ [H^+{}_{(aq)}]^2}{[H_2O_{(l)}]\ [Cr_2O_7^{2-}{}_{(aq)}]}$

___ 8. Which one of the following would NOT favor the forward reaction?

a) Addition of more potassium chromate.
b) Increasing the concentration of hydrochloric acid.
c) Decreasing the temperature of the solution.
d) Addition of water.

NUMERICAL RESPONSE 3:

Use the following to answer the next question:

0.1 mol/L Solutions			
1	$NaNO_2(aq)$	3	$HNO_3(aq)$
2	$NaHCO_3(aq)$	4	$Ba(OH)_2(aq)$

When the solutions above are ordered from most basic to least basic, the order is: 4, 2, 1, and 3.

___ 9. Vinegar, an aqueous solution of acetic acid, is used to preserve and flavour food. Most of the vinegar used for this purpose has an acetic acid concentration of 0.83 mol/L. The vinegar used in food has a:

$CH_3COOH(aq) + H_2O(aq) \rightleftharpoons CH_3COO^-(aq) + H_3O^+(aq)$

a) $[H_3O^+(aq)]$ equal to $[CH_3COO^-(aq)]$
b) $[H_3O^+(aq)]$ greater than $[CH_3COOH(aq)]$
c) $[CH_3COO^-(aq)]$ equal to $[CH_3COOH(aq)]$
d) $[CH_3COO^-(aq)]$ greater than $[H_3O^+(aq)]$

___ 10. Nitrogen dioxide is a dark brown gas, which can decompose to form dinitrogen tetraoxide. The mixture of these two gases will eventually reach equilibrium.

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

Which of the following statements is NOT true?

a) At equilibrium, both of these reactions have ceased.
b) At equilibrium the color of the gas mixture would remain constant.
c) At equilibrium, the rate of decomposition of NO_2 to N_2O_4 equals its rate of formation.
d) At equilibrium, the quantities of NO_2 and N_2O remain the same.

Use the following equilibrium to answer the next question

$$\underset{1}{HSO_4^-(aq)} + \underset{2}{HCOO^-(aq)} \leftrightarrow \underset{3}{HCOOH(aq)} + \underset{4}{SO_4^{2-}(aq)}$$

NUMERICAL RESPONSE 4:

Match each acid or base in the FORWARD reaction, as numbered above, with the corresponding term below.

Acid ___1___
Conjugate Base ___4___
Base ___2___
Conjugate Acid ___3___

___ 11. Which one of the following oxides would you expect to be BASIC?

a) SO_2
b) NO_2
c) Li_2O
d) CO_2

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___ 12. Consider the following statements.

1. Acids are substances which produce hydrogen ions in aqueous solution.
2. Acids are proton donors.
3. Bases are substances which ionize in water to produce hydroxide ions.
4. A base is a proton acceptor.

Which, if any, are consistent with the Arrhenius theory of acids and bases?

a) 1 only.
b) 1 and 2.
c) 2 and 4.
d) 1 and 3.

___ 13. Which of the following examples shows only strong acids?

a) Hydrochloric acid, ethanoic acid, sulfuric acid
b) Sulfuric acid, nitric acid, hydrochloric acid
c) Ethanoic acid, carbonic acid, nitric acid
d) Nitric acid, phosphoric acid, sulfuric acid

___ 14. A substance which reacts with both acids and bases is said to be

a) amphiprotic
b) a good oxidising agent
c) an electrolyte
d) hydrated

___ 15. The hydrogen carbonate ion, HCO_3^-, may act as an acid or a base in aqueous solution. In which one of the equations below is it acting as an acid?

a) $HCO_3^-(aq) + H_2O(l) \rightleftharpoons H_2CO_3(aq) + OH^-(aq)$
b) $HCO_3^-(aq) + H_3O^+(aq) \rightleftharpoons H_2CO_3(aq) + H_2O(l)$
c) $HCO_3^-(aq) + H_2O(l) \rightleftharpoons CO_3^{-2}(aq) + H_3O^+(aq)$
d) $HCO_3^-(aq) + OH^-(aq) \rightleftharpoons H_2CO_3(aq) + O^{2-}(aq)$

The next 2 questions refer to the following equations

- I $Mg(s) + 2H_3O^+(aq) \Rightarrow Mg^{2+}(aq) + H_2(g) + 2H_2O(l)$
- II $H_3O^+(aq) + OH^-(aq) \rightleftharpoons 2H_2O(l)$
- III $HS^-(aq) + H_3O^+(aq) \rightleftharpoons H_2S(aq) + H_2O(l)$

___ 16. Which of the above equation/s represents acid – base reaction/s?

a) I only b) I and II c) II and III d) II only e) I, II and III.

___ 17. Which of the following is acting as a base?

a) Mg(s) b) $H_3O^+(aq)$ c) $H_2S(aq)$ d) $HS^-(aq)$

___ 18. In the neutralization reaction between aqueous solutions of hydrochloric acid and sodium hydroxide, the spectator ions are

a) $H^+(aq)$ and $OH^-(aq)$
b) $Na^+(aq)$ and $H^+(aq)$
c) $Na^+(aq)$ and $Cl^-(aq)$
d) $OH^-(aq)$ and $Cl^-(aq)$

___ 19. In a chemistry laboratory, two reagent bottles are labelled 1.0M sulfuric acid and 10.0M ethanoic acid. Based on this information and your knowledge of acids, which of the following statement/s uses correct terminology?

a) The ethanoic acid is more concentrated than the sulphuric acid.
b) The ethanoic acid is stronger than the sulphuric acid
c) The sulphuric acid solution is weaker than the ethanoic acid solution.
d) The ethanoic acid solution is more dilute than the sulphuric acid solution
e) Both statements a and b above are correct

___ 20. The $[H^+]$ concentration in pure water at 25°C is equal to

a) 1 mol/ L
b) 10^{-14} mol/ L
c) 7 mol/ L
d) 10^{-7} mol/ L

___ 21. The equation below shows the reaction of ammonia with water:

$$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

According to the Bronsted-Lowry theory of acids and bases, the water molecules in the above reaction

a) act as an acid by giving up a proton.
b) act as a base by accepting a proton.
c) act as an acid by neutralizing the ammonia.
d) act as an acid by giving up electrons.

___ 22. For the following reaction, $NH_4^+(aq) + HPO_4^{2-}(aq) \rightleftharpoons NH_3(aq) + H_2PO_4^-(aq)$, the conjugate acid of $HPO_4^{2-}(aq)$ is

a) $NH_4^+(aq)$
b) $NH_3(aq)$
c) $H_2PO_4^-(aq)$
d) $H_3O^+(aq)$

___ 23. What is the pH of a 0.01 mol/L sodium hydroxide solution?

a) 0.01
b) 2
c) 12
d) 14

___ 24. Which of the following best defines a strong acid?

a) A strong acid has a high concentration of hydrogen ions.
b) A strong acid is one which fully ionizes in aqueous solution.
c) A strong acid has a pH of less than 2.
d) A strong acid is one which turns blue litmus red.

___ 25. Which of the following aqueous solutions has the lowest pH?

a) 0.1 mol/L NaOH(aq)
b) 0.1 mol/L HNO_3(aq)
c) 0.1 mol/L H_2SO_4(aq)
d) 0.1 mol/L HF(aq)

___ 26. Which of the following equations represents an equilibrium system that favours the products?

a) $HOCl(aq) + HCO_3^-(aq) \leftrightarrow OCl^-(aq) + H_2CO_3(aq)$
b) $H_2SO_3(aq) + CN^-(aq) \leftrightarrow HSO_3^-(aq) + HCN(aq)$
c) $HF(aq) + NO_2^-(aq) \leftrightarrow F^-(aq) + HNO_2(aq)$
d) $H_2S(aq) + F^-(aq) \leftrightarrow HS^-(aq) + HF(aq)$

NUMERICAL RESPONSE 5:

$$NH_{3\,(g)} + H_2O_{(l)} \Leftrightarrow NH_4^+{}_{(aq)} + OH^-{}_{(aq)} \quad K_C = 1.76 \times 10^{-5}\ mol/L$$

-assumption rule

For the equation above, when the initial concentration of NH_3(aq) is 0.250 mol/L, the equilibrium concentration of OH^- (aq) is a.bc $\times 10^{-d}$ mol/L. Record the values a, b, c, and d.

2, 1, 0, 3
a b c d

___ 27. The table below shows acid dissociation constants, K_a , for four acids, measured at 25°C.

ACID	FORMULA	DISSOCIATION CONSTANT
Hydrofluoric Acid	HF(aq)	6.8×10^{-4}
Ethanoic Acid	CH_3COOH(aq)	1.8×10^{-5}
Oxalic Acid	$H_2C_2O_4$(aq)	5.4×10^{-2}
Hydrogen Carbonate Ion	HCO_3^-(aq)	5.6×10^{-11}

Which is the WEAKEST acid shown in the table above?

a) HF(aq)
b) CH_3COOH (aq)
c) $H_2C_2O_4$(aq)
d) HCO_3^-(aq)

___ 28. Which of the following solutions contains the most hydrogen ions?

a) 10 mL of 0.1 mol/L CH_3COOH(aq)
b) 10 mL of 0.1 mol/L HCl(aq)
c) 10 mL of 0.1 mol/L H_2SO_4(aq)
d) 10 mL of 0.1 mol/L H_2CO_3(aq)

___ 29. $2SO_2(g) + O_2(g) \leftrightarrow 2\ SO_3(g)$

At 900 K, the equilibrium constant for the reaction is 13.0. The equilibrium concentrations are:

$[SO_2(g)] = 0.361$ mol/L

$[SO_3(g)] = 0.840$ mol/L

Given the values above, the calculated equilibrium concentration of $O_2(g)$ is

a) 0.179 mol/L
b) 0.416 mol/L
c) 2.40 mol/L
d) 5.59 mol/L

$$\frac{(0.84)^2}{(0.361)^2 X}$$

___ 30. At equilibrium in this gaseous system

$$2A + B \leftrightarrow 2C + D$$

[A] = 2.00 mol/L, [B] = 1.20 mol/L, [C] = 3.00 mol/L, and [D] = 0.600 mol/L. What is the numerical value of the equilibrium constant?

a) 4.32
b) 1.33
c) 1.13
d) 0.889

$$\frac{3^2 \cdot (0.6)}{2^2 \cdot (1.2)}$$

NUMERICAL RESPONSE 6:

$$CO(g) + H_2O(g) \leftrightarrow CO_2(g) + H_2(g) \quad K_C = 4.2 \text{ at } 900\ ^\circ C$$

In a 500 mL steel reaction vessel at 900 °C, 2.00 mol of carbon monoxide and 2.00 mol of water vapour react to produce carbon dioxide and hydrogen. The concentration of carbon dioxide at equilibrium will be 2.69 mol/L. (Record your answer to three significant digits)

	$[CO(g)]$	$[H_2O(g)]$	$[CO_2(g)]$	$[H_2(g)]$
I	4 mol/L	4 mol/L	0	0
C	$-x$	$-x$	$+x$	$+x$
E	$4-x$	$4-x$	x	x

$$4.2 = \frac{x^2}{(4-x)^2}$$

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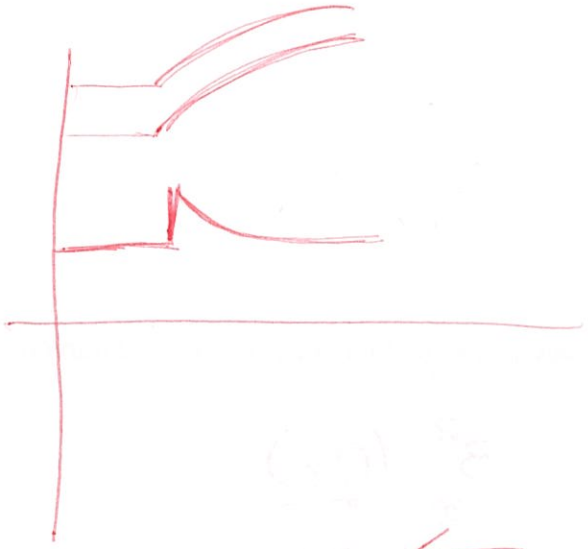

$$A + B \rightleftharpoons C + D + \text{energy} \qquad K_c <$$

$$\frac{P_1 V_1}{T_1}$$

$$\frac{221.30\ g}{1\ mol} = \frac{0.9\ g}{x\ mol}$$