

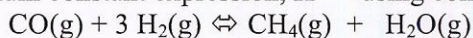
Numerical constants may be listed below. Other needed information is given in the problem or written on the board or found in the periodic tables you will use during exam. For numerical problems, be sure to **show your work**, include units and circle your final answer. If several choices are given, **circle the correct answer**. Your written answers should be brief and to the point. You can use only your own calculator on the exam, but no notes, books, external information, or other electronic devices are to be used. No cell phone is to be used in Exam room.

$$1 \text{ cal} = 4.184 \text{ J} \quad c = 3.00 \times 10^8 \text{ m/s} \quad 1 \text{ atm} = 760 \text{ torr} = 1.01 \times 10^5 \text{ N/m}^2 \quad h = 6.63 \times 10^{-34} \text{ Js}$$

$$R = 0.08206 \text{ (L atm/ mol K)} \text{ or } R = 8.31 \text{ J/mol K} \quad 1 \text{ g} = 6.02 \times 10^{23} \text{ amu}$$

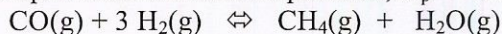
$$^{\circ}\text{C} = (^{\circ}\text{F} - 32)/1.8 \quad \text{K} = ^{\circ}\text{C} + 273$$

1) Write the equilibrium constant expression, K_c using concentrations for the reaction



$$K_c = \frac{[\text{CH}_4][\text{H}_2\text{O}]}{[\text{CO}][\text{H}_2]^3}$$

2) Write the pressure equilibrium constant expression, K_p using partial pressures for the reaction



$$K_p = \frac{P_{\text{CH}_4} P_{\text{H}_2\text{O}}}{P_{\text{CO}} P_{\text{H}_2}^3}$$

3) If the value of the equilibrium constant is $K=3.92$ at a temperature of 1200K and the reaction quotient is $Q=50$ then to reach equilibrium which of the following must occur

reactants go to products or products go to reactants

$Q > K$
too much products

4) For the reaction $\text{CO(g)} + \text{H}_2\text{O(g)} = \text{CO}_2\text{(g)} + \text{H}_2\text{(g)}$

with $K=0.58$ at 1000°C if the initial concentrations are

$[\text{CO}] = [\text{H}_2\text{O}] = 0.0200\text{M}$ $[\text{CO}_2] = [\text{H}_2] = 0$ then at equilibrium the concentration of CO_2 is

$$K = \frac{[\text{CO}_2][\text{H}_2]}{[\text{CO}][\text{H}_2\text{O}]}$$

$$0.58 = \frac{[x][x]}{[.020-x][.020-x]}$$

$$(0.58)^{1/2} = \frac{x}{.020-x}$$

$$.762 = \frac{x}{.020-x}$$

$$\begin{aligned} .762(.020-x) &= x \\ 0.0152 - .762x &= x \\ .0152 &= 1.762x \\ \frac{.0152}{1.762} &= x \end{aligned}$$

$$0.00863 = x$$

$$[\text{CO}_2] = 0.00863$$

$$8.63 \times 10^{-3} \text{ M}$$

For the reaction $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) + \text{heat}$
 according to LeChatelier's principle each of the following changes will cause what response and change in equilibrium if any – Indicate the correct answer for each question below.

5) increase temperature cause shift to left right no change

6) increase H_2 concentration cause shift to left right no change

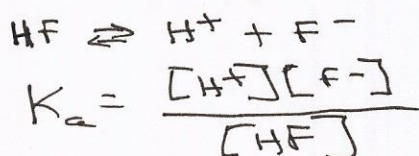
7) As the amount of carbon dioxide is increased in the atmosphere due to the burning of fossil fuels, we would expect, from Le Chatelier's Principle, that the amount of CO_2 in the ocean to (circle one) increase or decrease and the ocean therefore to become (circle one) more acidic or more basic.

8) If HNO_2 is a stronger acid than HCN then which is the stronger base
 NO_2^- or CN^-

9) A 0.10M solution of $HCl(aq)$ has a pH =

$$\begin{aligned} pH &= -\log [0.10] \\ &= -(-1.0) \\ \text{pH} &= 1.0 \end{aligned}$$

10) A 0.10M solution of $HF(aq)$ with $K_a = 6.8 \times 10^{-4}$ has a pH =



$$6.8 \times 10^{-4} = \frac{[x][x]}{[0.10 - x]}$$

$$6.8 \times 10^{-4} \approx \frac{x^2}{.10} \quad \text{since } K_a \text{ is small}$$

$$\begin{aligned} 6.8 \times 10^{-5} &= x^2 \\ (6.8 \times 10^{-5})^{1/2} &= (x^2)^{1/2} \end{aligned}$$

$$0.00825 = x = [H^+]$$

$$pH = -\log(0.00825)$$

$$\text{pH} = 2.08$$

11) If the pH of a solution is 2.00 then the OH^- concentration is $[OH^-] =$

$$\begin{aligned} pH + pOH &= 14 \\ pOH &= 14 - pH \\ &= 14 - 2.00 \\ pOH &= 12.00 \end{aligned}$$

$$\begin{aligned} [OH^-] &= 10^{-pOH} \\ &= 10^{-12.00} \end{aligned}$$

$$[OH^-] = 1 \times 10^{-12} M$$

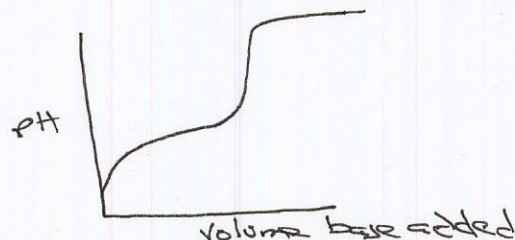
12) If 0.100M solution of acetic acid $HC_2H_3O_2$ ($K_a = 1.8 \times 10^{-5}$) is present in a 0.100M solution of the strong electrolyte sodium acetate $NaC_2H_3O_2$ then the concentration of hydronium ions, H_3O^+ will be $[H^+] =$

$$K_a = \frac{[H^+][C_2H_3O_2^-]}{[HC_2H_3O_2]}$$

$$1.8 \times 10^{-5} = \frac{[H^+][0.100]}{[0.100]}$$

$$1.8 \times 10^{-5} M = [H^+]$$

13) The titration shown is for a weak acid with a strong base.
 weak strong binary neutral



14) Acid-base chemistry is important in medicine. In uncontrolled diabetes with too little insulin then free fatty acids may be broken down for energy releasing carboxylic acids into the blood. This is an example of

metabolic acidosis metabolic alkalosis respiratory acidosis respiratory alkalosis

15) Recall that $\Delta G^\circ = -RT \ln K$. In a chemical reaction at 298K if the equilibrium constant is 2×10^5 then the standard free energy ΔG° (kJ/mol) is

$$\Delta G^\circ = - \left(8.31 \frac{\text{J}}{\text{mol K}} \right) (298\text{K}) \ln (2 \times 10^5)$$

$$= - 30227 \frac{\text{J}}{\text{mol}}$$

$$\Delta G^\circ = - 30.2 \frac{\text{kJ}}{\text{mol}}$$

16) A reaction will favor products if

$\Delta G > 0$ $\Delta G = 0$ $K \ll 1$ $K \gg 1$

17) Which of the following is the strongest acid in water

HF HCl HBr HI

because I⁻ biggest

18) Which of the following is the strongest acid

HClO HClO₂ HClO₃ HClO₄

because most oxygen atoms

19) If $K_{sp} = 2.4 \times 10^{-5}$ for CaSO₄ then in a saturated solution of CaSO₄ the concentration of calcium ions will be $[\text{Ca}^{2+}] =$

$$K_{sp} = [\text{Ca}^{2+}][\text{SO}_4^{2-}]$$

$$2.4 \times 10^{-5} = [x][x]$$

$$2.4 \times 10^{-5} = x^2$$

$$0.0049 = x$$

$$[\text{Ca}^{2+}] = 4.9 \times 10^{-3} \text{ M}$$

20) Write the K_{sp} expression for AlCl₃

$$K_{sp} = [\text{Al}^{3+}][\text{Cl}^-]^3$$

21) Recall that CN⁻ is the conjugate base of a weak acid. When sodium cyanide is dissolved into water, Na⁺ and CN⁻ ions are released into water. A reaction then occurs to make the solution basic. Complete the reaction below.

