CHEMISTRY 1B – Fall, 2015
EXAM 1 – VERSION A

Use Scantron Form SC982-E and select the letter corresponding to the correct answer. Make sure to put **your full name, lab section number, and exam version** (under test no.) on the Scantron Form.

Equations and constants that you could need: 0°C = 273 K; $K_w = 1.0 \times 10^{-14}$

The quadratic equation for $ax^2 + bx + c = 0$ is $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

A periodic table is provided on the last page along with a blank page to be used as scratch paper.

Part I. Multiple Choice Section. All Questions have only one correct answer. Each Question is worth 4 points.

1. The reaction $2NO_2(g) \leftrightarrow N_2O_4(g)$ is at equilibrium. This means that:
a) No molecules of reactant or product are being converted any longer
b) For every 2 molecules of NO_2 that react to form N_2O_4, one of ~~NO_2~~ N_2O_4 reacts backwards.
c) The rate constants for the forward reaction and backwards reaction are equal
d) The forward and backwards rates have decreased to zero

2. Given the K values for the two reactions (with the right side called a "complex"):
$Cu^{2+}(aq) + 4NH_3(aq) \rightleftharpoons Cu(NH_3)_4(aq)$ $K = 8 \times 10^8$ and
$Hg^{2+}(aq) + 4NH_3(aq) \rightleftharpoons Hg(NH_3)_4(aq)$ $K = 2 \times 10^{19}$, we can conclude:
a) Cu^{2+} complexes weakly with NH_3
b) Hg^{2+} complexes more strongly with NH_3 than Cu^{2+}
c) NH_3 is a poor Lewis base
d) Cu^{2+} and Hg^{2+} would remain mostly uncomplexed even with NH_3 present

3. Which of the following concentration based equilibrium equations correctly corresponds to the following chemical equation: $2CO(g) + 4H_2(g) \rightleftharpoons C_2H_5OH(g) + H_2O(g)$?

a) $K_C = \frac{[CO][H_2]}{[C_2H_5OH][H_2O]}$

b) $K_C = \frac{[CO]^2[H_2]^4}{[C_2H_5OH][H_2O]}$

c) $K_C = \frac{[C_2H_5OH][H_2O]}{[CO][H_2]}$

d) $K_C = \frac{[C_2H_5OH][H_2O]}{[CO]^2[H_2]^4}$

4. In the reaction: $CO_3^{2-}(aq) + CO_2(g) + H_2O(l) \rightleftharpoons 2HCO_3^-(aq)$, all of the species except ____ will be included in the equilibrium equation.
a) $CO_3^{2-}(aq)$ b) $CO_2(g)$ c) $H_2O(l)$ d) $HCO_3^-(aq)$

5. For the reaction $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$, If the initial partial pressure of N_2, H_2, and NH_3 are 10.0, 10.0 and 0 atm and the equilibrium partial pressure of NH_3 is 6.0 atm, K_P =
a) 3.6×10^{-3} b) 0.06 c) 0.14 d) 5.1

6. Sulfur gases leaving a power plant exhaust stack have P_{SO2} and P_{SO3} equal to 1.0×10^{-2} atm and 5.0×10^{-4} atm, respectively and enter the air. If K_P for the reaction $2SO_2(g) + O_2(g) \leftrightarrow 2SO_3(g)$ is 320, in which direction with the reaction proceed if $P_{O2} = 0.20$ atm?

a) to the products b) to the reactants
c) it is at equilibrium d) depends on ΔH

7. If K_C for the reaction $2Na_2O_2(s) + 2CO_2(g) \rightleftharpoons 2Na_2CO_3(s) + O_2(g)$ is 6.3×10^4, what is the equilibrium concentration of CO_2 in M if the equilibrium concentration of O_2 is 0.0100 M?

a) 1.6×10^{-7} b) 4.0×10^{-4} c) 2.0×10^{-4} d) 0.020 M

8. The reaction $2N_2(g) + O_2(g) \rightleftharpoons 2N_2O(g)$ starts with $P_{N2} = 0.79$ atm, $P_{O2} = 0.20$ atm (and no N_2O) and proceeds to an equilibrium. The ICE table **equilibrium** partial pressures of N_2, O_2 and N_2O (bottom row of table) will be:

a) 0.79 - x and 0.20 - x, and +x, respectively b) 0.79 - 2x and 0.20 - x, and +2x, respectively
c) 0.79 + x and 0.20 + x, and -x, respectively d) 0.79^2, 0.2, and $2x^2$, respectively

9. If at 1000°C, $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ has $K = 2.0 \times 10^{-9}$ and $N_2(g) + 2O_2(g) \rightleftharpoons 2NO_2(g)$ has K = 38, then $2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$ has K =

a) 5.3×10^{-11} b) 7.6×10^{-8} c) 38 d) 1.9×10^{10}

10. The reaction $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ reaches an equilibrium in a sealed 1.0 L flask. This reaction is endothermic. Which of the following changes will result in a shift toward the products?

a) decreasing the flask temperature b) increasing the flask volume
c) adding a catalyst d) removing through N_2O_4 condensation

11. In the reaction: $Al(H_2O)_6^{3+}(aq) + H_2O(l) \rightleftharpoons Al(H_2O)_5OH^{2+}(aq) + H_3O^+(aq)$, the Bronsted-Lowry acid (in the direction shown) is:

a) $Al(H_2O)_6^{3+}(aq)$ b) $H_2O(l)$ c) $Al(H_2O)_5OH^{2+}(aq)$ d) $H_3O^+(aq)$

12. A Lewis acid is defined as a:

a) a compound that produces H^+ in water b) a proton donor
c) an electron pair acceptor d) a positively charged acid

13. Which of the following salt solutions is neutral?

a) KOH b) NH_4Cl c) Na_2CO_3 d) KNO_3

14. Which of the following acids has the strongest conjugate base (conjugate base with the greatest K_b)?

a) HSO_4^- ($pK_a = 2.00$) b) HF ($pK_a = 3.17$)
c) $N_2H_5^+$ ($pK_a = 7.98$) d) HCN ($pK_a = 9.24$)

15. What is the pH of a 0.0050 M $Ba(OH)_2$ solution? (Note: K_w given on p. 1)

a) 0.01 b) 2.00 c) 11.70 d) 12.00

16. A solution has a pH of 4.89. $[H^+]$ is:
a) 7.8×10^{-10} b) 1.3×10^{-5} c) 7.5×10^{-3} d) 0.69

17. What is the pH of a 0.20 M $HC_2H_3O_2$ acid ($K_a = 1.8 \times 10^{-5}$)?
a) 0.70 b) 2.72 c) 4.74 d) 7.00

18. An unknown weak acid is prepared to an initial concentration of 0.010 M. The pH is measured to be 3.16. The percent ionization of that weak acid is:
a) 0.16% b) 3.3% c) 6.9% d) 135%

19. A polyprotic acid is **defined as** an acid which:
a) releases two or more protons per molecule b) is a polymer that is acidic
c) has both acid and base functional groups d) all of the above

20. Which of the following combinations makes the best buffer?
a) HCl + NaCl b) $NH_4Cl + NH_3$ c) $HC_2H_3O_2 + HCl$ d) $KOH + H_2O$

21. Fluorine is the most electronegative element and it stabilizes electron rich anions. Based on this, which of the following acids would be expected to be the strongest?
a) CH_3CO_2H b) CFH_2CO_2H c) CF_2HCO_2H d) CF_3CO_2H

22. How many moles of sodium acetate should be added to a 1.0 L solution of 0.040 M acetic acid to make a pH = 5.00 buffer? (acetic acid $K_a = 1.8 \times 10^{-5}$)
a) 0.023 moles b) 0.050 moles c) 0.070 moles d) 1.00 moles

23 - Bonus. Given K_a values below, which anion will make an acidic solution?
a) HPO_4^{2-} b) HCO_3^- c) $HC_8H_4O_4^-$ d) $C_2H_3O_2^-$

Acid	K_{a1}	K_{a2}	K_{a3}
H_3PO_4	7.1×10^{-3}	6.3×10^{-8}	4.2×10^{-13}
H_2CO_3	4.5×10^{-6}	4.7×10^{-11}	NA
$H_2C_8H_4O_4$	1.1×10^{-3}	3.9×10^{-6}	NA
$HC_2H_3O_2$	1.8×10^{-5}	NA	NA

Work out Problem (12 pts) – Answer on the back of the Scantron and show work
Consider the following equation:

$$2H_2S(g) \leftrightarrow 2H_2(g) + S_2(g) \quad K_C = 1.91 \times 10^{-8} \text{ (at 1000 K)}$$

If the initial concentration of $H_2S(g)$ was 0.060 M and the other species were at zero, what is the equilibrium concentration of the product, $H_2(g)$? <u>You must show your work for full credit. If you make any simplifying assumptions, show and validate them.</u>