CHEMISTRY 1B – Fall, 2015
EXAM 2 – 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 $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

R = Universal Gas Constant = 8.314 J mol^{-1} K^{-1}

$\Delta G_{rxn} = \Delta G_{rxn}° + RT\ln Q$ $\Delta G° = \Delta H° - T\Delta S°$

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.

Use the following information to answer questions 1 to 3. A buret is filled with 0.100 M HCl and it is used to titrate 35.0 mL of an unknown strong base. The titration requires 44.57 mL of HCl to reach the equivalence point.

1. The original concentration of OH^- in the unknown strong base is:
a) 0.0785 M b) 0.127 M c) 0.156 M d) 0.254 M e) 1.56 M

2. The pH after adding 40.0 mL of HCl will be:
a) 1.00 b) 1.25 c) 1.92 d) 11.788 e) 13.11

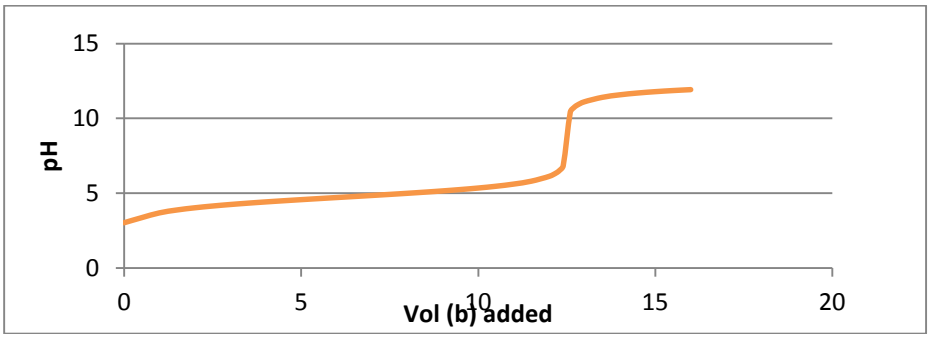
3. The pH at the equivalence point will be:
a) 2.8 b) 4.5 c) 7.0 d) 9.0 e) 11.5

4. Methyl amine (CH_3NH_2 – $K_b = 4.35 \times 10^{-4}$) is a weak base and is being titrated with a strong acid. The pH at one half of the volume needed to reach the equivalence point will be:
3.36 b) 5.32 c) 7.00 d) 10.64 e) 10.94

5. A weak base is titrated by a strong acid. Which indicator (in general based on the indicator's pK_a value) would be the best for determining the endpoint?
a) Thymolphthalein ($pK_a = 10.0$) b) Phenolphthalein ($pK_a = 9.1$)
c) Bromcresol blue ($pK_a = 6.8$) d) Methyl red ($pK_a = 5.00$)

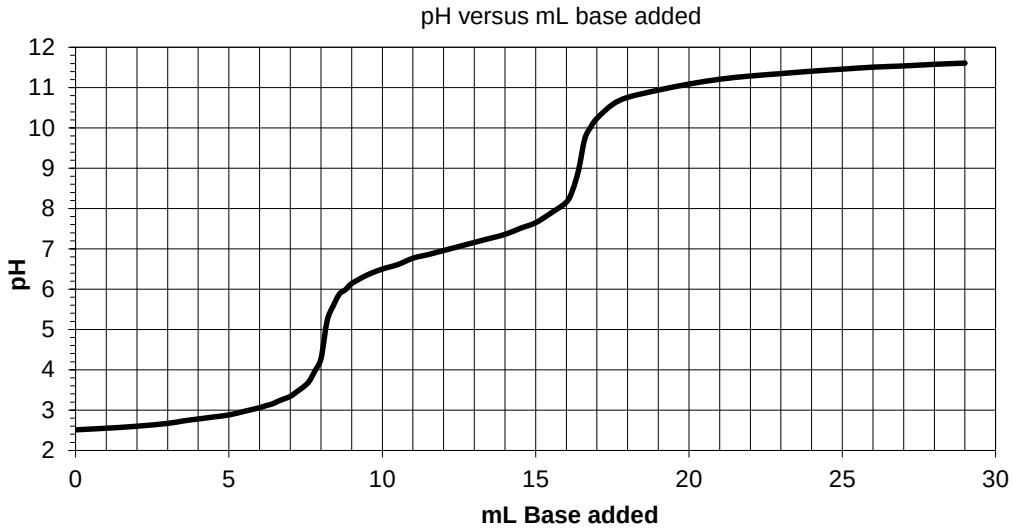
6. Lead (II) chloride ($PbCl_2$) has a $K_{sp} = 1.17 \times 10^{-5}$. Its molar solubility in water is:
a) 3.42×10^{-3} M b) 1.43×10^{-2} M c) 1.80×10^{-2} M d) 2.27×10^{-2} M e) 4.67×10^{-2} M

7. Looking at the following titration plot below, we can conclude that it is the titration of a _____ where (a) is in the container with the pH meter and (b) is added.



a) Strong acid (a) by a strong base (b) b) Strong base (a) by a strong acid (b)
c) Monoprotic weak acid (a) by a strong base (b)
d) A Strong base (a) by a weak acid (b)
e) A diprotic weak base (a) by a strong acid (b)

8. The plot below shows the titration of a diprotic weak acid by a strong base, the pK_{a2} is approximately,



a) 2.8 b) 4.5 c) 7.0 d) 9.0 e) 11.5

9. Solid silver phosphate (Ag_3PO_4) is added to water to make a saturated solution. Which of the following additions will **decrease** the equilibrium concentration of Ag^+?
a) Na_3PO_4 b) HNO_3 c) NH_3 (forms complex ion) d) more $Ag_3PO_4(s)$

10. Which of the following sparingly salts will see NO INCREASE in solubility with the addition of HNO_3?
a) $CaCO_3$ b) $Mg(OH)_2$ c) AgCl d) $AlPO_4$ e) $ZnCO_3$

11. What is the concentration of Mg^{2+} when $Mg(OH)_2$ solid is placed in a pH = 10.00 buffer? Assume the buffer pH is constant. K_{sp} $(Mg(OH)_2) = 2.06 \times 10^{-13}$.
a) 4.5×10^{-7} M b) 2.1×10^{-5} M c) 4.7×10^{-5} M d) 2.1×10^{-1} M e) 2.1×10^{14} M

12. Zinc oxalate, ZnC_2O_4, is a sparingly soluble salt ($K_{sp} = 2.7 \times 10^{-8}$). However, $C_2O_4^{2-}$ also acts as a ligand with Zn^{2+}, forming $Zn(C_2O_4)_3^{4-}$ with a $K_f = 1.4 \times 10^8$. If oxalate anion is present at an **equilibrium concentration** of 0.010 M in a solution containing solid zinc oxalate and reaches an equilibrium with respect to all ions, $[Zn(C_2O_4)_3^{4-}]$ will =
a) 1.0×10^{-7} M b) 2.8×10^{-6} M c) 3.8×10^{-4} M d) 2.3×10^{-1} M e) 3.8 M

13. Silver chloride is an insoluble salt but can be dissolved by adding NH_3 which forms the complex ion $Ag(NH_3)_2^+$. After dissolving AgCl by addition of NH_3, addition of HNO_3 results in the re-precipitation of Ag^+ because:
a) H^+ removes Cl^- to form HCl making AgCl less soluble
b) all nitrate salts are insoluble, so $AgNO_3$ precipitates
c) H^+ converts NH_3 to NH_4^+ so it is no longer a Lewis base to complex Ag^+
d) the K_{sp} for AgCl is lower in the presence of NO_3^-
e) all of the above

14. In which of the following reactions will the entropy increase?
a) $I_2(aq) \leftrightarrow I_2(s)$ b) $I_2(s) + Br_2(aq) \leftrightarrow 2IBr(aq)$ c) $I_2(g) \leftrightarrow I_2(s)$
d) $2I(g) \leftrightarrow I_2(g)$ e) $I_2(aq) + I^-(aq) \leftrightarrow I_3^-(aq)$

15. When any spontaneous reaction occurs, $\Delta S_{universe}$ is
a) positive b) negative c) opposite in sign of ΔS_{system}
d) of the same sign as $\Delta S_{surroundings}$

16. For the reaction $N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g)$, $\Delta H° = -91.8$ kJ/mol. This reaction is spontaneous for:
a) no temperatures b) for low temperatures
c) for high temperatures d) all temperatures

Use the table below to answer questions 17 and 18

Compound	$\Delta H_f°$ (kJ mol^{-1})	S° (J mol^{-1} K^{-1})	$\Delta G_f°$ (kJ mol^{-1})
CO(g)	-110.5	197.7	-137.2
H_2(g)	0	130.7	0
CH_3OH(g)	-201.0	239.9	-162.3

17. Calculate K (equilibrium constant) at 298 K for the reaction $CO(g) + 2H_2(g) \leftrightarrow CH_3OH(g)$
a) 4.0×10^{-5} b) 0.97 c) 1.0 d) 2.5×10^4 e) 1.4×10^{10}

18. At what temperature will $\Delta G°$ for the reaction $CO(g) + 2H_2(g) \leftrightarrow CH_3OH(g)$ be 0?
a) 0.5 K b) 120 K c) 205 K d) 413 K e) 1111 K

19. The reaction $H_2(g) + I_2(s) \leftrightarrow 2HI(g)$ has a $\Delta G° = +3.4$ kJ mol^{-1}. If a system starts with $P_{H2} = 0.85$ atm and $P_{HI} = 0.010$ atm and T = 298K, ΔG =
a) -19 kJ mol^{-1} b) -9.5 kJ mol^{-1} c) -7.6 kJ mol^{-1} d) +3.4 kJ mol^{-1} e) +19 kJ mol^{-1}

20. Which of the following cations will **not be precipitated** by the addition of Cl^- and of SO_4^{2-} (successively in a separation scheme)?
a) Na^+ b) Pb^{2+} c) Ag^+ d) Ba^{2+}

21. Hydrazine (N_2H_4) is used to make rocket fuel and other products but it has positive ΔG_f over all temperatures. A strategy to make it would be to:
a) make from N_2 and H_2, but using higher temperatures
b) make from N_2 and H_2, but use catalysts
c) use a more stable reactant than H_2 (such as CH_4)
d) use a less stable reactant than N_2 (such as N_2O)
e) have the reaction also produce another unstable product (such as N_3)

22. Which of the following substances has the lowest entropy?
a) $Br_2(g)$ at room temperature b) $Br_2(l)$ at 0°C c) $Br_2(s)$ at 0°C
d) $Br_2(s)$ at 0 K e) Br(g) at 1000 K

23 - Bonus. A mixture is expected to contain 0.010 M SO_4^{2-} and 0.010 M $C_2O_4^{2-}$. If the K_{sp} values for $BaSO_4$ and BaC_2O_4 are 1.1×10^{-10} and 1.0×10^{-6}, respectively, the maximum percent of SO_4^{2-} that can be precipitated without precipitating any $C_2O_4^{2-}$ is:
a) 0% b) 0.01% c) 91% d) 99.99% e) 99.999%

****

Work out Problem (12 pts) – Answer on the back of the Scantron and show work
25.0 mL of a 0.0810 M acetic acid ($K_a = 1.8 \times 10^{-5}$) is being titrated by 0.100 M NaOH. Determine: a) the volume of base needed to reach the equivalence point and b) the pH (to 3 sig figs) of the titration solution at the equivalence point. <u>You must show your work for full credit. If you make any simplifying assumptions, show and validate them.</u>