Chemistry 123
Exam 1

Spring 2010
April 22, 2010

Oregon State University
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DO NOT OPEN THIS EXAM UNTIL INSTRUCTED. CALCULATORS ARE NOT TO BE SHARED.

Test Form 1

Instructions: You should have with you several number two pencils, an eraser, your 3" x 5" note card, a calculator, and your University ID Card. If you have notes with you, place them in a sealed backpack and place the backpack OUT OF SIGHT or place the notes directly on the table at the front of the room.

Fill in the front page of the Scantron answer sheet with your test form number (listed above), last name, first name, middle initial, and student identification number. **Leave the class section number blank.**

This exam consists of 25 multiple-choice questions. Each question has four points associated with it. Select the best multiple-choice answer by filling in the corresponding circle on the rear page of the answer sheet. If you have any questions before the exam, please ask. If you have any questions during the exam, please ask the proctor. Open and start this exam when instructed. When finished, place your Scantron form in the appropriate stack. You may keep the exam packet, so please show your work and mark the answers you selected on it.

$K_a[CH_3COOH\ (aq)] = 1.80 \times 10^{-5}$ (acetic acid)	$K_a[C_6H_5COOH\ (aq)] = 6.30 \times 10^{-5}$ (benzoic acid)
$K_a[CH_2ClCOOH\ (aq)] = 1.40 \times 10^{-3}$ (chloroacetic acid)	$K_b[NH_3\ (aq)] = 1.80 \times 10^{-5}$ (ammonia)
$K_a[HCOOH\ (aq)] = 1.80 \times 10^{-4}$ (formic acid)	K_{sp} [$PbCl_2$, lead chloride] $= 1.6 \times 10^{-5}$
K_{sp} [PbF_2, lead fluoride] $= 3.6 \times 10^{-8}$	K_{sp} [MgF_2, magnesium fluoride] $= 3.7 \times 10^{-8}$

IA	IIA	IIIB	IVB	VB	VIB	VIIB	VII			1B	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1 H Hydrogen 1.0079																	2 He Helium 4.0026
3 Li Lithium 6.941	4 Be Beryllium 9.01218											5 B Boron 10.81	6 C Carbon 12.011	7 N Nitrogen 14.0067	8 O Oxygen 15.9994	9 F Fluorine 18.9984	10 Ne Neon 20.179
11 Na Sodium 22.98977	12 Mg Magnesium 24.305											13 Al Aluminum 26.9815	14 Si Silicon 28.0855	15 P Phosphorus 30.97376	16 S Sulfur 32.06	17 Cl Chlorine 35.453	18 Ar Argon 39.948
19 K Potassium 39.0983	20 Ca Calcium 40.08	21 Sc Scandium 44.9559	22 Ti Titanium 47.88	23 V Vanadium 50.9415	24 Cr Chromium 51.996	25 Mn Manganese 54.9380	26 Fe Iron 55.847	27 Co Cobalt 58.9332	28 Ni Nickel 58.70	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.72	32 Ge Germanium 72.59	33 As Arsenic 74.9216	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.9059	40 Zr Zirconium 91.22	41 Nb Niobium 92.9064	42 Mo Molybdenum 95.94	43 Tc Technetium 98.906	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.9055	46 Pd Palladium 106.4	47 Ag Silver 107.868	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.69	51 Sb Antimony 121.75	52 Te Tellurium 127.60	53 I Iodine 126.9045	54 Xe Xenon 131.30
55 Cs Cesium 132.9054	56 Ba Barium 137.33	57–71 *Rare earths	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.2	77 Ir Iridium 192.22	78 Pt Platinum 195.09	79 Au Gold 196.9665	80 Hg Mercury 200.59	81 Tl Thallium 204.37	82 Pb Lead 207.2	83 Bi Bismuth 208.9804	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium 226.0254	89–103 †Actinides	104 Rf Rutherfordium (261)	105 Ha Hahnium (262)	106 Sg Seaborgium (263)	107 Ns Neilsbohrium (262)	108 Hs Hassium (265)	109 Mt Meitnerium (266)	110 ‡ (269)	111 ‡			114				

1. The pH of 0.655 M HCl (aq) is: ← strong acid

$HCl(aq) \xrightarrow{100\%} H^+(aq) + Cl^-(aq)$

0.655 M → 0.655 M

$pH = -\log[H^+] = -\log(0.655) = 0.184$

(A) 0.345
(B) (0.184)
(C) 0.655
(D) 0.736
(E) 4.74

2. The pH of 0.212 M aqueous dimethylamine, C_2H_7N, $K_b = 4.79 \times 10^{-4}$, is: ← weak base – K_b is given

(A) 2.00
(B) (12.00)
(C) 13.8
(D) 0.674
(E) 13.3

$C_2H_7N(aq) + H_2O(l) \rightleftharpoons C_2H_7NH^+(aq) + OH^-(aq)$

0.212 − x → x → x

$K_b = 4.79 \times 10^{-4} = \frac{[C_2H_7NH^+][OH^-]}{[C_2H_7N]} = \frac{x^2}{0.212 - x} \approx \frac{x^2}{0.212}$

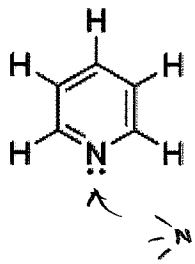
$x = [OH^-] = 0.0101$

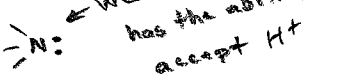
$pOH = -\log[OH^-] = -\log(0.0101) = 2.00$

$pH + pOH = 14$

$pH = 14 - pOH = 14 - 2.00 = 12.00$

3. Pyridine, shown below, is:





(A) a strong acid
(B) a weak acid
(C) a strong base
(D) (a weak base)
(E) a polymer

4. The $[OH^-]$ of 0.0500 M HNO_3 (aq) is: ← strong acid

(A) -1.30 M
(B) 1.30 M
(C) 12.7 M
(D) 2.00×10^{-13} M
(E) 0.0500 M

$HNO_3(aq) \xrightarrow{100\%} H^+(aq) + NO_3^-(aq)$

0.0500 M 0.0500 M

$pH = -\log[H^+] = -\log(0.0500) = 1.30$

$pH + pOH = 14$

$pOH = 14 - 1.30 = 12.70$

$[OH^-] = 10^{-pOH} = 10^{-12.70} = 2.00 \times 10^{-13}$ M

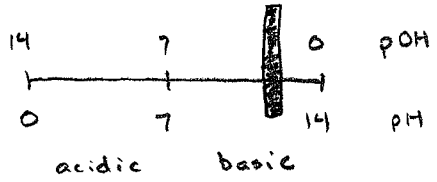
5. A student obtains an aqueous hydrochloric acid solution and measures the pH to be 0.923. What is the concentration of H^+?

(A) 0.119 M $[H^+]$
(B) 0.923 M $[H^+]$
(C) 0.0348 M $[H^+]$
(D) 13.9 M $[H^+]$
(E) 1.0×10^{-7} M $[H^+]$

$[H^+] = 10^{-pH} = 10^{-0.923} = 0.119$ M

6. A student measures the pOH of an aqueous solution to be 2.08. This solution is:

(A) acidic
(B) neutral
(C) basic



7. The pH of 0.200 M NH_4Cl (aq), is:

NH_4^+ acid — Cl^- spectator ion

(A) Greater than 7.00
(B) 7.00
(C) Less than 7.00

acidic

8. CH_3COONa (aq) is:

CH_3COO^- is a weak base — Na^+ is a spectator ion

(A) an acid
(B) a base
(C) is neither an acid or a base because it contains two spectator ions

9. Consider the reaction of benzoic acid, C_6H_5COOH (aq), and water. The conjugate base is:

(A) H_2O (l)
(B) OH^- (aq)
(C) H_3O^+ (aq)
(D) C_6H_5COOH (aq)
(E) $C_6H_5COO^-$ (aq)

$C_6H_5COOH(aq) + H_2O(l) \rightleftarrows C_6H_5COO^-(aq) + H_3O^+(aq)$

weak acid — base — conjugate base — conjugate acid

10. The pH of a buffer system which is 0.200 M HCOOH (aq) and 0.100 M HCOONa (aq) is:

(A) 3.44
(B) 4.05
(C) 3.78
(D) 1.87
(E) 2.22

$HCOOH(aq) \rightleftarrows HCOO^-(aq) + H^+(aq)$

$K_a = 1.80 \times 10^{-4} = \frac{[HCOO^-][H^+]}{[HCOOH]} = \frac{(0.100)[H^+]}{(0.200)}$

$[H^+] = 0.000360\ M$

$pH = -\log[H^+] = -\log(0.000360) = 3.44$

11. Which of the following three buffer systems has the **lowest** pH? ← most acid

(A) the aqueous buffer system which is $[CH_3COOH] = 1.00$ M and $[CH_3COONa] = 1.00$ M
(B) the aqueous buffer system which is $[CH_3COOH] = 1.00$ M and $[CH_3COONa] = 2.00$ M
(C) the aqueous buffer system which is $[CH_3COOH] = 2.00$ M and $[CH_3COONa] = 1.00$ M

12. A student titrates 0.413 grams of an unknown acid to the equivalence point with 29.15 mL of 0.0983 M NaOH (aq). The molecular mass of the unknown acid is:

(A) 1.18 g/mol
(B) 118 g/mol
(C) 207 g/mol
(D) 144 g/mol
(E) 0.694 g/mol

$M_{NaOH}V_{NaOH} = moles_{Acid}$ at the equivalence point

$(0.0983\ M)(0.02915\ L) = 0.00287$ mol Acid

Molar Mass $= \frac{g}{mol} = \frac{0.413\ g}{0.00287\ mol} = 144\ \frac{g}{mol}$

13. A student titrates 25.00 mL of HCl (aq) with 36.50 mL of 0.1502 M NaOH (aq) to reach the equivalence point. The concentration of HCl (aq) is:

(A) 0.1032 M
(B) 5.482×10^{-3} M
(C) 0.1322 M
(D) 7.000 M
(E) 0.2193 M

$M_{HCl}V_{HCl} = M_{NaOH}V_{NaOH}$ at the equivalence point

$(M_{HCl})(0.02500\ L) = (0.1502\ M)(0.03650\ L)$

$M_{HCl} = 0.2193\ M$

14. A student titrates 0.3400 grams of KHP (potassium hydrogen phthalate; MW=204.2 g/mol) to the equivalence point with 23.05 mL of NaOH (aq). The concentration of the NaOH solution is:

(A) 13.84 M
(B) 0.0722 M
(C) 0.3012 M
(D) 0.100 M
(E) 7.224×10^{-5} M

$M_{NaOH} V_{NaOH} = \frac{g_{KHP}}{MW_{KHP}}$

$(M_{NaOH})(0.02305\ L) = \frac{0.3400\ g}{204.2\ g/mol}$

$M_{NaOH} = 0.0722\ M$

15. ~~Which of the following selections contains only acids?~~

~~(A) HNO_3, CH_3COOH, CH_3CH_2COOH~~
~~(B) HNO_3, $NaNO_2$, HCl, NaCl~~
~~(C) H_2SO_4, HNO_3, HCl, NH_3~~
~~(D) NaOH, KOH, NH_4OH, $Ca(OH)_2$~~

15. Which of the following statements is true?

(A) All endothermic processes which result in a system of greater disorder are spontaneous
(B) All endothermic processes which result in a system of greater order are spontaneous
(C) All exothermic processes which result in a system of greater disorder are spontaneous
(D) All exothermic processes which result in a system of greater order are spontaneous

16. Which of the following reflects a decrease in entropy? → ΔS = (-)

(A) A spoonful of table sugar dispersing in water
(B) Water freezing $H_2O(l) \rightarrow H_2O(s)$
(C) Water boiling
(D) The evaporation of water
(E) The evaporation of alcohol

more order
ΔS = (-)

17. Which of the following processes exhibits an increase in entropy of the system?

(A) $N_2O_4(g) \rightarrow 2\,NO_2(g)$ one mol gas → two moles gas
(B) $CH_3OH(l) \rightarrow CH_3OH(s)$
(C) $H_2O(g) \rightarrow H_2O(s)$
(D) $CH_3OH(g) \rightarrow CH_3OH(l)$
(E) $2\,C_2H_2(g) + 5\,O_2(g) \rightarrow 4\,CO_2(g) + 2\,H_2O(g)$

18. Consider the combustion of propane, C_3H_8, in oxygen to form carbon dioxide and steam.

(A) ΔH = (+) ΔS = (+) ΔG = (-)
(B) ΔH = (+) ΔS = (-) ΔG = (-)
(C) ΔH = (-) ΔS = (+) ΔG = (-)
(D) ΔH = (-) ΔS = (-) ΔG = (-)

$C_3H_8(g) + 5\,O_2(g) \rightarrow 3\,CO_2(g) + 4\,H_2O(g)$

more disorder
ΔS = (+)

combustion ΔH = (-)

ΔG = (-) - (+)(+)

(-)
always

19. $\Delta H = -34$ kJ and $\Delta S = -845$ J/K for a process. Determine the temperature in which the system is at equilibrium?

(A) 287 K
(B) 28.7 K
(C) 24.9 K
(D) 0.0249 K
(E) (40.2 K)

$\Delta G = 0$ at equilibrium

$0 = \Delta H - T\Delta S = (-34\ kJ) - (T)(-.845\ kJ/K)$

$T = 40.2\ K$

20. Consider a process in which $K = 5.7 \times 10^{-6}$. ← small (smaller than 1)

(A) ΔG will be negative and the process is spontaneous
(B) ΔG will be positive and the process is spontaneous
(C) ΔG will be negative and the process is not spontaneous
(D) (ΔG will be positive and the process is not spontaneous)

$\Delta G = -RT\ln K$

$\Delta G = -(+)(+)(-) = (+)$

not spontaneous

21. The system MgO (s) + C (graphite) ↔ Mg (s) + CO (g) is allowed to reach equilibrium where q_{rev} is measured to be 468 kJ at 298 K. ΔS is:

(A) (1570 J/K)
(B) 1.39×10^5 J/K
(C) -170 J/K
(D) 766 J/K
(E) -1.39×10^5 J/K

$\Delta S = \frac{q_{rev}}{T} = \frac{468{,}000\ J}{298\ K} = 1570\ J/K$

more disorder
ΔS = (+)

ΔH = (+)
endothermic
(the cold pack has heat entering the system – cold surroundings)

22. Consider the "cold pack" reaction: NH_4NO_3 (s) → NH_4NO_3 (aq).

(A) ΔH = (-) ΔS = (+) ΔG = (-)
(B) ΔH = (-) ΔS = (-) ΔG = (-)
(C) ΔH = (+) ΔS = (+) ΔG = (-)
(D) ΔH = (+) ΔS = (-) ΔG = (-)

23. Determine ΔS for the reaction 4 PCl_3 (g) → P_4 (s) + 6 Cl_2 (g)
using the following two reactions:

Flip (1) P_4 (s) + 10 Cl_2 (g) → 4 PCl_5 (g) ΔS_1 = +1405 J/K

x4 (2) PCl_3 (g) + Cl_2 (g) → PCl_5 (g) ΔS_2 = -211 J/K

(1') 4 PCl_5 (g) → P_4 (s) + 10 Cl_2 (g) $\Delta S_1' = +1405$ J/K

(2') 4 PCl_3 (g) + 4 Cl_2 (g) → 4 PCl_5 (g) $\Delta S_2' = (-211\ J/K) * 4$

4 PCl_3 (g) → P_4 (s) + 6 Cl_2 (g) + 561 J/K

(A) +1249 J/K
(B) -1249 J/K
(C) +561 J/K ← +561 J/K
(D) +776 J/K
(E) +804 J/K

24.

Formula	ΔH°_f (kJ/mol)	ΔG°_f (kJ/mol)	S° (J/mol•K)
C_2H_2 (g)	226.7	209.2	200.9
O_2 (g)	0	0	205.1
CO_2 (g)	-393.5	-394.4	213.6
H_2O (g)	-241.8	-228.6	188.8

C_2H_2 (g) + 5/2 O_2 (g) → 2 CO_2 (g) + H_2O (g)

209.2 kJ/mol ∅ -394.4 kJ/mol -228.6 kJ/mol

$\Delta G^\circ_{reaction}$ for the combustion of acetylene, C_2H_2, is:

(A) -832.2 kJ and the reaction is spontaneous at 298 K
(B) +832.2 kJ and the reaction is not spontaneous at 298 K
(C) -413.8 kJ and the reaction is spontaneous at 298 K
(D) +413.8 kJ and the reaction is not spontaneous at 298 K
(E) -1226.6 kJ and the reaction is spontaneous at 298 K

ΔG°_{rxtn} = products - reactants

$= [(2\ mol\ CO_2)(-394.4\ kJ/mol) + (1\ mol\ H_2O)(-228.6\ kJ/mol)] - [(1\ mol\ C_2H_2)(209.2\ kJ/mol) + (\frac{5}{2}\ mol\ O_2)(\emptyset\ kJ/mol)]$

$= -1226.6\ kJ$

$\Delta G^\circ = (-)$ spontaneous

25. So, Exam 1 is over. And now…

(A) I need to work mom for some serious cash
(B) I'm going to play Scrabble on Facebook and spell "pentane" for 90 points
(C) I'm off to the ballpark
(D) Downtown with friends
(E) I need to write a letter to decline the Nobel Prize Committee's offer because the prize will place me in a higher tax bracket

[Any response will receive full credit; even no response.]