Chemistry 123 | Spring 2005 | Oregon State University
Exam 1 | April 21, 2005 | Dr. Richard Nafshun

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} [PbF_2, lead fluoride] $= 3.6 \times 10^{-8}$	K_{sp} [MgF_2, magnesium fluoride] $= 3.7 \times 10^{-8}$

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 0.040 M HNO_3 (aq) is:

(A) 0.040.
(B) 0.140.
(C) 1.40.
(D) 12.60.
(E) 13.96.

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

Strong Acid $\qquad$ 0.040M

$pH = -\log[H^+] = -\log(0.040) = 1.40$

2. The $[OH^-]$ of 0.040 M HCl (aq) is:

(A) 0.040 M.
(B) 0.140.
(C) 1.00×10^{-7} M.
(D) 2.51×10^{-13} M.
(E) 1.00×10^{-14} M.

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

Strong Acid $\qquad$ 0.040M

$pH = -\log[H^+] = -\log(0.040) = 1.40$

$pH + pOH = 14$

$pOH = 14 - pH = 14 - 1.40 = 12.60$

$[OH^-] = 10^{-pOH} = 10^{-12.60} = 2.51 \times 10^{-13}$ M

3. The pH of 0.150 M C_6H_5COOH (aq) is:

(A) 0.150.
(B) 0.300.
(C) 2.51.
(D) 2.74.
(E) 3.74.

	$C_6H_5COOH(aq)$	$\rightleftarrows C_6H_5COO^-(aq)$ +	$H^+(aq)$
I	0.150	0	0
C	$-x$	$+x$	$+x$
E	$0.150 - x$	x	x

$K_a = 6.30 \times 10^{-5} = \dfrac{[C_6H_5COO^-][H^+]}{[C_6H_5COOH]} = \dfrac{x^2}{0.150 - x}$

$x = [H^+] = 0.00307$ M

$pH = -\log[H^+] = -\log(0.00307)$

$pH = 2.51$

4. The pOH of an aqueous system is measured to be 3.46. The pH of this system is:

(A) 0.539
(B) 3.46.
(C) 3.47×10^{-4}.
(D) 7.46.
(E) 10.54.

$pH + pOH = 14$

$pH = 14 - pOH = 14 - 3.46 = 10.54$

5. The pH of a buffer system which is 1.30 M $CH_2ClCOOH$ (aq) and 1.30 M $CH_2ClCOONa$ (aq) is:

(A) 1.30.
(B) 1.50.
(C) 2.85.
(D) 3.00.
(E) 6.00.

$CH_2ClCOOH\ (aq) \rightleftarrows CH_2ClCOO^-\ (aq) + H^+\ (aq)$

1.30 M 1.30 M

$K_a = 1.40 \times 10^{-3} = \frac{[CH_2ClCOO^-][H^+]}{[CH_2ClCOOH]} = \frac{(1.30)[H^+]}{(1.30)}$

$[H^+] = 1.40 \times 10^{-3}$ M

$pH = -\log[H^+] = -\log(1.40 \times 10^{-3}) = 2.85$

6. Which buffer system has the LOWEST pH?

→ Most acid

(A) 0.50 M C_6H_5COOH (aq) and 0.50 M C_6H_5COONa (aq)
(B) 1.00 M C_6H_5COOH (aq) and 0.50 M C_6H_5COONa (aq)
(C) 0.50 M C_6H_5COOH (aq) and 1.00 M C_6H_5COONa (aq)

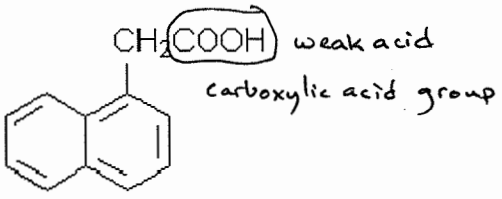
↑ acid ↑ base

7. Consider CH_3COOH, $CH_2ClCOOH$, and C_6H_5COOH. The **strongest** acid is:

		K_a
(A)	CH_3COOH.	1.8×10^{-5}
(B)	$CH_2ClCOOH$.	1.4×10^{-3}
(C)	C_6H_5COOH.	6.3×10^{-5}

↓ Greatest K_a

8. Consider the molecule below.



This molecule is:

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

9. A student titrates 0.550 grams of KHP (potassium hydrogen phthalate; MW=204.2 g/mol) to the equivalence point with 36.60 mL of NaOH (aq). The concentration of the NaOH solution is:

(A) 3069 M.
(B) 13.6 M.
(C) 0.0913 M.
(D) 0.100 M.
(E) (0.0736 M.)

At the equivalence point: $\text{Moles}_{NaOH} = \text{Moles}_{KHP}$

$$M_{NaOH} V_{NaOH} = \frac{\text{grams KHP}}{\text{MW KHP}}$$

$$(M_{NaOH})(0.03660\,L) = \frac{0.550\,g}{204.2\,g/mol}$$

$$M_{NaOH} = 0.0736\,M$$

10. Consider the reaction of formic acid (HCOOH), and water. The conjugate base is:

(A) HCOOH.
(B) NH_3.
(C) ($HCOO^-$.)
(D) H^+.
(E) H_3O^+.

$HCOOH(aq) + H_2O(\ell) \rightleftharpoons HCOO^-(aq) + H_3O^+$

acid — base — conjugate base — conjugate acid

11. The pH of 1.00 M sodium acetate, CH_3COONa (aq), is:

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

CH_3COO^- is a base ($pH > 7$)

$CH_3COO^- + H_2O \rightleftharpoons CH_3COOH + OH^-$

Na^+ is a spectator ion

12. A student titrates 35.00 mL of HCl (aq) with 18.22 mL of 0.2004 M NaOH (aq) to reach the equivalence point. The concentration of HCl (aq) is:

(A) 0.3850 M.
(B) (0.1043 M.)
(C) 0.1322 M.
(D) 1.41×10^{-3} M.
(E) 9.586 M.

At the equivalence point: $\text{moles}_{NaOH} = \text{moles}_{HCl}$

$$M_{NaOH} V_{NaOH} = M_{HCl} V_{HCl}$$

$$(0.2004\,M)(18.22\,mL) = (M_{HCl})(35.00\,mL)$$

$$M_{HCl} = 0.1043\,M$$

13. Which of the following selections contains only acids?

(A) HNO_3, $NaNO_3$, HCl, NaCl.
(B) NaOH, KOH, NH_4OH, $Ca(OH)_2$.
(C) H_2SO_4, HNO_3, HCl, NH_3.
(D) HNO_3, CH_3COOH, CH_3CH_2COOH.

Strong Weak Weak Acids

14. The solubility of MgF_2 is:

(A) 1.9×10^{-11} M.
(B) 1.9×10^{-8} M.
(C) 1.9×10^{-7} M.
(D) 2.1×10^{-3} M.
(E) 1.4×10^{-2} M

$MgF_2(s) \rightleftarrows Mg^{2+}(aq) + 2F^-(aq)$

$x \qquad 2x$

$K_{sp} = 3.7 \times 10^{-8} = [Mg^{2+}][F^-]^2 = (x)(2x)^2 = 4x^3$

x = solubility of $MgF_2 = 2.1 \times 10^{-3}$ M

15. A solution was made 3.0×10^{-3} M in $[Pb^{2+}]$ and 2.5×10^{-3} M in $[F^-]$.

(A) A precipitate will form.
(B) A precipitate will not form.

$PbF_2(s) \rightleftarrows Pb^{2+}(aq) + 2F^-(aq)$

$K_{sp} = 3.6 \times 10^{-8}$

$Q = [Pb^{2+}][F^-]^2 = (3.0 \times 10^{-3})(2.5 \times 10^{-3})^2$

$Q = 1.88 \times 10^{-8}$

$Q < K$ (No ppt will form — not enough ion is present to saturate the solution).

16. Consider the combustion of octane: $2\ C_8H_{18}\ (l) + 25\ O_2\ (g) \rightarrow 16\ CO_2\ (g) + 18\ H_2O\ (g)$ $\Delta H = (-)$ Exothermic

25 mol gas → 34 mol gas

$\Delta S = (+)$ More disorder

$\Delta G = (-)$ Spontaneous

(A) $\Delta H = (+)$, $\Delta S = (+)$, and $\Delta G = (-)$.
(B) $\Delta H = (+)$, $\Delta S = (-)$, and $\Delta G = (-)$.
(C) $\Delta H = (-)$, $\Delta S = (+)$, and $\Delta G = (-)$.
(D) $\Delta H = (-)$, $\Delta S = (-)$, and $\Delta G = (-)$.

17. 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.

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

See Question # 16 for an example

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

(A) $\Delta H = (-)$, $\Delta S = (+)$, and $\Delta G = (-)$.
(B) $\Delta H = (-)$, $\Delta S = (-)$, and $\Delta G = (-)$.
(C) $\Delta H = (+)$, $\Delta S = (+)$, and $\Delta G = (-)$.
(D) $\Delta H = (+)$, $\Delta S = (-)$, and $\Delta G = (-)$.

spontaneous
endothermic
more disorder

19. Consider the process: CO_2 (s) → CO_2 (g).

more disorder

(A) ΔS is negative.
(B) ΔS is positive.

$\Delta S = (+)$

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

more disorder

(A) NH_4NO_3 (aq) → NH_4NO_3 (s)
(B) H_2O (l) → H_2O (s)
(C) H_2O (s) → H_2O (g)
(D) $2\ NO_2$ (g) → N_2O_4 (g)
(E) CH_3CH_2OH (g) → CH_3CH_2OH (l)

21. $\Delta H^\circ = -123$ kJ and $\Delta S^\circ = -203$ J/K for a process. Determine ΔG° at 298 K.

(A) -62.5 kJ.
(B) +62.5 kJ.
(C) - 60,371 kJ.
(D) +183 kJ.
(E) -183 kJ.

$\Delta G = \Delta H - T\Delta S = (-123\ kJ) - (298\ K)\left(-0.203\ \frac{kJ}{K}\right) = -62.5\ kJ$

22. Given the following reactions:

Flip and divide by 2

$2SO_2\,(g) + O_2\,(g) \rightarrow 2SO_3\,(g)$ $\quad \Delta S_1 = -196$ J/K

$2S\,(s) + 3O_2\,(g) \rightarrow 2SO_3\,(g)$ $\quad \Delta S_2 = -790$ J/K

Divide by 2

Calculate the change in entropy for:

$S\,(s) + O_2\,(g) \rightarrow SO_2\,(g)$ $\quad \Delta S_3 = ?$

(A) $\Delta S_3 = -790$ J/K.
(B) $\Delta S_3 = -199$ J/K.
(C) $\Delta S_3 = -986$ J/K.
(D) $\Delta S_3 = +986$ J/K.
(E) $\Delta S_3 = -297$ J/K.

$SO_3 \rightarrow SO_2 + \frac{1}{2}O_2$ $\quad \Delta S_1 = +98$ J/K

$S + \frac{3}{2}O_2 \rightarrow SO_3$ $\quad \Delta S_2 = -395$ J/K

$S + O_2 \rightarrow SO_2$ $\quad \Delta S_3 = -297$ J/K

23. $\Delta H° = -102$ kJ and $\Delta S° = -224$ J/K for a process. Determine the temperature in which the system is at equilibrium?

$\Delta G = \Delta H - T\Delta S$

$0 = (-102\text{ kJ}) - (T)(-0.224\ \frac{kJ}{K})$

$T = 455$ K

(A) 298 K.
(B) 455 K.
(C) 300 K.
(D) 0 K.
(E) 4 K.

24. Consider the process: $2\,CO_2\,(g) \rightarrow 2\,CO\,(g) + O_2\,(g)$

2 mol gas → 3 mol gas

more disorder

$\Delta S = (+)$

(A) ΔS is negative.
(B) ΔS is positive.

25. Because of Chemistry 123...

(A) I am staying 15 degrees cooler than my non-chemistry friends.
(B) My penmanship has improved.
(C) My batting average has increased from .285 to .460.
(D) I am motivated to invent a better tasting sports drink.
(E) I am changing my major to chemistry and my last name to Boltzmann... today!
[Any response will receive full credit; even no response.]