KEY

Chemistry 123 | Spring 2006 | Oregon State University
Exam 1 | April 27, 2006 | 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} [$PbCl_2$, lead chloride] $= 1.6 \times 10^{-5}$
K_{sp} [PbF_2, lead fluoride] $= 3.6 \times 10^{-8}$	K_{sp} [MgF_2, magnesium fluoride] $= 3.7 \times 10^{-8}$

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 0.020 M HCl (aq) is:

(A) 0.020
(B) 1.70
(C) 1.40
(D) 3.22
(E) 13.98

$HCl \xrightarrow[100\%]{} H^+ + Cl^-$

$0.020\ M\ H^+$

$pH = -\log[H^+] = -\log(0.020) = 1.70$

2. The pH of 0.020 M CH_3COOH (aq) is:

(A) 0.020
(B) 1.70
(C) 1.40
(D) 3.22
(E) 13.98

$K_a = 1.8 \times 10^{-5} = \frac{x^2}{0.020}$ where $x = [H^+]$

$x^2 = 3.60 \times 10^{-7}$

$x = [H^+] = 6.00 \times 10^{-4}$

$pH = -\log[H^+] = -\log(6.00 \times 10^{-4}) = 3.22$

3. A student measures the pH of an aqueous solution to be 3.27. The $[OH^-]$ of this solution is:

(A) 1.86×10^{-11} M
(B) 1826 M
(C) 5.37×10^{-4} M
(D) 10.73 M
(E) -0.515 M

$pH = 3.27$

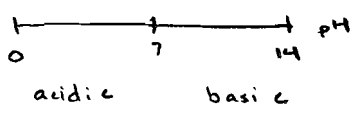
$pH + pOH = 14$

$pOH = 14 - pH = 14 - 3.27 = 10.73$

$[OH^-] = 10^{-pOH} = 10^{-10.73} = 1.86 \times 10^{-11}$ M

4. A student measures the pH of an aqueous solution to be 2.40. This solution is:

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



5. The pH of an aqueous system is measured to be 4.00. The pOH of this system is:

(A) 4.00
(B) 7.00
(C) 3.00
(D) 10.00
(E) 11.00

pH = 4.00
pOH = 14.00 - 4.00 = 10.00

6. The pH of a buffer system which is
0.225 M CH_3CH_2COOH (aq) and 0.225 M CH_3CH_2COONa (aq) is 4.88.

The pH of a buffer system which is
0.225 M CH_3CH_2COOH (aq) and 0.450 M CH_3CH_2COONa (aq) is:

Acid BASE

(A) 4.88
(B) greater than 4.88
(C) less than 4.88

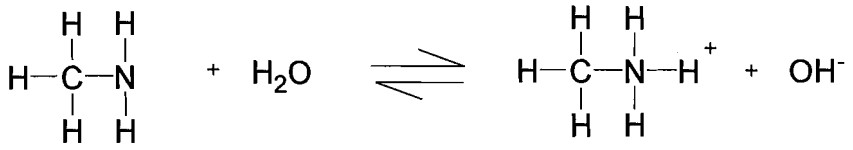
↑ More Base - Higher pH than 4.88

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

(A) HCl — Strong Acid
(B) CH_3COOH.
(C) $CH_2ClCOOH$.
(D) C_6H_5COOH.

} Weak acids

8. Methylamine (pictured below) has a lone pair of electrons on the nitrogen, can accept a proton, and is in equilibrium with methylammonium ion in water.



methylamine methylammonium ion

Methylamine is:

(A) a strong acid
(B) a weak acid
(C) a strong base
(D) a weak base → weak because of equilibrium arrows
(E) neither an acid or a base base because it accepts a proton

9. 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

$\text{moles}_{KHP} = \text{moles}_{NaOH}$

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

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

$M_{NaOH} = 0.0722\ M$

10. Consider the reaction of acetic acid (CH_3COOH) and water. The conjugate base is:

(A) H^+ or H_3O^+
(B) NH_3
(C) H_2O
(D) CH_3COO^-
(E) CH_3COOH

$CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$

acid conjugate base

11. The pH of 1.00 M ammonium nitrate, NH_4NO_3 (aq), is:

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

NH_4^+ NO_3^- spectator ion

$NH_4^+ \rightleftharpoons NH_3 + H^+$

NH_4^+ acid

lowers pH

12. A student titrates 25.00 mL of HCl (aq) with 28.44 mL of 0.1025 M NaOH (aq) to reach the equivalence point. The concentration of HCl (aq) is:

(A) 8.576 M
(B) 0.0901 M
(C) 11.10 M
(D) 72.88 M
(E) 0.1166 M

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

$(M_{HCl})(25.00\ mL) = (28.44\ mL)(0.1025\ M)$

$M_{HCl} = 0.1166\ M$

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.

14. The solubility of $PbCl_2$ is:

(A) 1.6×10^{-8} M
(B) 4.0×10^{-8} M
(C) 0.0040 M
(D) 1.6×10^{-5} M
(E) 0.016 M

$PbCl_2(s) \rightleftharpoons Pb^{2+}(aq) + 2Cl^-(aq)$

$x \quad 2x$

$K_{sp} = 1.6 \times 10^{-5} = [Pb^{2+}][Cl^-]^2$

$x \quad (2x)^2$

$1.6 \times 10^{-5} = (x)(2x)^2$

$\frac{1.6 \times 10^{-5}}{4} = \frac{4x^3}{4}$

$x^3 = 4.00 \times 10^{-6}$

$x = 0.016$ = solubility of $PbCl_2$

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

15. A solution was made 0.40 M in $[Pb^{2+}]$ and 0.40 M in $[F^-]$. $K_{sp} = 3.6 \times 10^{-8}$

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

$Q = [Pb^{2+}][F^-]^2$

$Q = (0.40)(0.40)^2 = 0.064$

$Q > K$ Therefore, a solid precipitate will form

16. Consider the combustion of acetylene, C_2H_2: $C_2H_2(g) + 5/2\ O_2(g) \rightarrow 2\ CO_2(g) + H_2O(g)$

(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 $\Delta G = (-)$

$3\frac{1}{2}$ moles gas → 3 moles gas

more order $\Delta S = (-)$

Combustion - exothermic
$\Delta H = (-)$

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.

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

$(-) = (-) - (+)(+)$

18. Consider the "cold pack" reaction: $NH_4NO_3\ (s) \rightarrow NH_4NO_3\ (aq)$.

more disorder $\Delta S = (+)$

endothermic $\Delta H = (+)$

(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 $\Delta G = (-)$

19. Consider the process: $H_2O\ (g) \rightarrow H_2O\ (l)$.

more order

$\Delta S = (-)$

(A) ΔS is negative
(B) ΔS is positive

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

more disorder

(A) $NH_4NO_3\ (aq) \rightarrow NH_4NO_3\ (s)$ ×
(B) $H_2O\ (l) \rightarrow H_2O\ (s)$ ×
(C) $H_2O\ (s) \rightarrow H_2O\ (g)$
(D) $2\ NO_2\ (g) \rightarrow N_2O_4\ (g)$ × (2 moles going to 1 mole gas)
(E) $CH_3CH_2OH\ (g) \rightarrow CH_3CH_2OH\ (l)$ ×

21. $\Delta H = -144$ kJ and $\Delta S = -163$ J/K for a process. Determine the temperature in which the system is at equilibrium?

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

$0 = (-144\ kJ) - (T)(-0.163\ \frac{kJ}{K})$

$T = 883\ K$

(A) 19.0 K
(B) 23.5 K
(C) 298 K
(D) 883 K
(E) 1900 K

22. Given the following reactions:

Flip $N_2(g) + O_2(g) \rightarrow 2\,NO(g)$ $\Delta S_1 = +23$ J/K

Flip $2\,NO(g) + O_2(g) \rightarrow 2\,NO_2(g)$ $\Delta S_2 = -630$ J/K

1 Flip → $2\,NO(g) \rightarrow N_2(g) + O_2(g)$ $\Delta S_1' = -23\ J/K$

2 Flip → $2\,NO_2(g) \rightarrow 2\,NO(g) + O_2(g)$ $\Delta S_2' = +630\ J/K$

$2\,NO_2(g) \rightarrow N_2(g) + 2\,O_2(g)$ $\Delta S_3 = +607\ J/K$

Calculate the change in entropy for:

$2\,NO_2(g) \rightarrow N_2(g) + 2\,O_2(g)$ $\Delta S_3 = ?$

(A) $\Delta S_3 = -584$ J/K
(B) $\Delta S_3 = +653$ J/K
(C) $\Delta S_3 = -653$ J/K
(D) $\Delta S_3 = +607$ J/K
(E) $\Delta S_3 = -607$ J/K

23. $\Delta H^\circ = -203$ kJ and $\Delta S^\circ = +371$ J/K for a process. Determine ΔG° at 300 K.

(A) -151 kJ.
(B) +151 kJ.
(C) -591 kJ.
(D) +591 kJ.
(E) -314 kJ.

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

$\Delta G = (-203\ kJ) - (300\ K)(+0.371\ kJ/K)$

$\Delta G = -314\ kJ$

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

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

2 mol gas → 3 mol gas

more disorder

25. Mars theories are in the news again (water, ice caps…) The worst thing about the pictures coming back from mars is:

(A) I've been staring at so much red lately, everything else I look at appears in the inverse color.

(B) I've enjoyed them so much, I fell behind on my homework—for the first time ever.

(C) no one wants to party. All my friends would rather wait by the computer for a new batch of images than play.

(D) I've spent over $400.00 on ink jet cartridges this week.

(E) they make me home sick.

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