Chemistry 123
Exam 1

Spring 2008
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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 0.515 M H_2SO_4 (aq) is:

(A) 3.14
(B) 1.57
(C) 0.0269
(D) (0.288)
(E) 0.718

$H_2SO_4(aq) \xrightarrow{100\%} H^+(aq) + HSO_4^-(aq)$

Strong Acid

$\downarrow$

0.515 M

$pH = -\log[H^+]$

$pH = -\log(0.515) = 0.288$

2. 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

$C_6H_5COOH(aq) \rightleftharpoons C_6H_5COO^-(aq) + H^+(aq)$

Weak Acid

I	0.150	0	0
C	$-x$	$+x$	$+x$
E	$0.150-x$	x	x

$K_a = 6.3\times10^{-5} = \frac{[C_6H_5COO^-][H^+]}{[C_6H_5COOH]} = \frac{x^2}{0.150-x}$ ← out

$x = [H^+] = 0.00310$ $pH = -\log(0.0031) = 2.51$

3. 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)

$pH + pOH = 14$

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

4. A student measures the $[H^+]$ in an aqueous solution to be 8.0×10^{-3} M. This solution is:

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

$pH = -\log[H^+] = -\log(8.0\times10^{-3}) = 2.10$

$pH < 7$ therefore acidic

5. The pH of an aqueous system is measured to be 9.00. The $[OH^-]$ of this system is:

(A) 1.00×10^{-5} M
(B) 1.00×10^{-9} M
(C) 9.00×10^{-7} M
(D) 9.00 M
(E) 5.00 M

$pH = 9.00 \quad pOH = 14 - 9.00 = 5.00$

$[OH^-] = 10^{-pOH} = 10^{-5.00} = 1.00 \times 10^{-5}$ M

6. The pH of a buffer system which is 0.300 M C_6H_5COOH (aq) and 0.300 M C_6H_5COONa (aq) is:

(A) 0.300
(B) 1.00
(C) 3.00
(D) 4.20
(E) 7.00

Na^+ is a spectator ion

$C_6H_5COOH(aq) \rightleftharpoons C_6H_5COO^-(aq) + H^+(aq)$

0.300 M 0.300 M

$K_a = 6.30 \times 10^{-5} = \frac{[C_6H_5COO^-][H^+]}{[C_6H_5COOH]} = \frac{(0.300)[H^+]}{(0.300)}$

$[H^+] = 6.30 \times 10^{-5}$

$pH = -\log[H^+] = -\log(6.30 \times 10^{-5}) = 4.20$

7. Which of the following three buffer systems has the **highest** pH? Basic

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

More Base than Acid

8. A student titrates 0.677 grams of an unknown acid to the equivalence point with 22.44 mL of 0.1022 M NaOH (aq). The molecular mass of the unknown acid is:

(A) 3.39×10^{-3} g/mol
(B) 0.295 g/mol
(C) 339 g/mol
(D) 204 g/mol
(E) 295 g/mol

$$\text{moles}_{Acid} = \text{moles}_{Base}$$

$$\frac{\text{grams}_{Acid}}{\text{MWT Acid}} = M_{Base} V_{Base}$$

$$\frac{(0.677\text{ g})}{\text{MWT}_{Acid}} = (0.1022\text{ M})(0.02244\text{ L})$$

$$\text{MWT Acid} = 295 \frac{\text{g}}{\text{mol}}$$

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

(A) HCOOH
(B) OH^-
(C) NH_4^+
(D) H^+
(E) $HCOO^-$

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

Acid — Base — Conjugate Base — Conjugate Acid

10. The pH of 1.00 M NH_4NO_3 (aq), is:

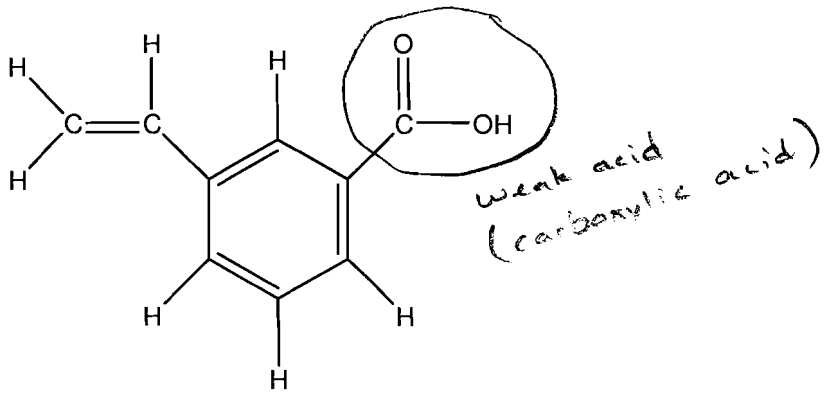
(A) Greater than 7.00
(B) 7.00
(C) Less than 7.00

NH_4NO_3

NH_4^+ Acid

NO_3^- spectator ion

11. The compound:



weak acid (carboxylic acid)

(A) is a strong acid
(B) is a weak acid
(C) is a strong base
(D) is a weak bas

12. A student titrates 25.00 mL of HCl (aq) with 43.25 mL of 0.0926 M NaOH (aq) to reach the equivalence point. The concentration of HCl (aq) is:

(A) 6.24 M
(B) 5.35×10^{-3} M
(C) 0.0535 M
(D) 18.7 M
(E) 0.160 M

$M_{Acid} V_{Acid} = M_{Base} V_{Base}$

$(M_{Acid})(0.02500\ L) = (0.0926\ m)(0.04325\ L)$

$M_{acid} = 0.1602\ M$

13. Which of the following does not reflect an increase in entropy?

(A) Water on the table evaporating
(B) The Universe expanding
(C) Opening up a bottle of perfume
(D) Water condensing on a cold glass on a hot day (months from now)

14. Consider the "cold pack" reaction. Which of the following statements is correct?

more disorder

NH_4NO_3 (s) → NH_4NO_3 (aq) $\Delta H = +50.6$ kJ

endothermic

(A) The process is endothermic; entropy decreases.
(B) The process is endothermic; entropy increases.
(C) The process is exothermic; entropy decreases.
(E) The process is exothermic; entropy increases.

15. $\Delta H° = -201$ kJ and $\Delta S° = +288$ J/K for a process. Determine $\Delta G°$ at 298 K.

→ $+0.288 \frac{kJ}{K}$

(A) - 287 kJ
(B) - 87 kJ
(C) - 115 kJ
(D) + 57.9 kJ
(E) + 225 kJ

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

$= (-201\ kJ) - (298\ K)(+0.288 \frac{kJ}{K})$

=

16. 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.

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

(-) (-) − (+)(+)

always

17. $\Delta H = -102$ kJ and $\Delta S = -304$ J/K for a process. Determine the temperature in which the system is at equilibrium.

(A) -193 K
(B) 193 K
(C) 202 K
(D) 336 K
(E) 406 K

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

$0 = (-102\text{ kJ}) - (T)(-0.304\ \frac{\text{kJ}}{\text{K}})$

$T = 336\text{ K}$

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

(A) $NH_4NO_3\,(aq) \rightarrow NH_4NO_3\,(s)$
(B) $H_2O\,(l) \rightarrow H_2O\,(s)$
(C) $2\,C_8H_{18}(l) + 25\,O_2(g) \rightarrow 16\,CO_2(g) + 18\,H_2O(g)$
(D) $2\,NO_2\,(g) \rightarrow N_2O_4\,(g)$
(E) $CH_3CH_2OH\,(g) \rightarrow CH_3CH_2OH\,(l)$

25 moles of gas → 34 moles of gas (more disorder)

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

(A) $H_2O\ (g) \rightarrow H_2O\ (l)$
(B) $CO_2\ (g) \rightarrow CO_2\ (s)$
(C) $CH_3OH\ (l) \rightarrow CH_3OH\ (s)$
(D) $N_2\ (l) \rightarrow N_2\ (g)$ → (l) to (g) more disorder
(E) $2\ C_2H_2(g) + 5\ O_2(g) \rightarrow 4\ CO_2(g) + 2\ H_2O(g)$

20. For the freezing of water:

(A) ΔS is negative (l) → (s) more order
(B) ΔS is positive.

21. Given the following reactions:

Flip $4\ PCl_3\ (g) \rightarrow P_4\ (s) + 6\ Cl_2\ (g)$ $\Delta G_1 = +142$ kJ
×4 $PCl_3\ (g) + Cl_2\ (g) \rightarrow PCl_5\ (g)$ $\Delta G_2 = -11$ kJ

Calculate the change in free energy entropy for:

$P_4\ (s) + 10\ Cl_2\ (g) \rightarrow PCl_5\ (g)$ $\Delta G_3 = ?$

(A) $\Delta G_3 = +131$ J/K
(B) $\Delta G_3 = +98$ J/K
(C) $\Delta G_3 = -186$ J/K
(D) $\Delta G_3 = -131$ J/K
(E) $\Delta G_3 = -153$ J/K

$P_4 + 6\ Cl_2 \rightarrow 4\ PCl_3$ ΔG = −142 kJ

$4\ PCl_3 + 4\ Cl_2 \rightarrow 4\ PCl_5$ ΔG = (4)x −11 kJ

$P_4 + 10\ Cl_2 \rightarrow 4\ PCl_5$ ΔG = −186 kJ

22. Calculate $\Delta S^\circ_{reaction}$ (298 K) for N_2 (g) + 3 H_2 (g) → 2 NH_3 (g)

Formula	S° (J/mol•K)
N_2 (g)	191.6
H_2 (g)	130.7
NH_3 (g)	192.5

$N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$

$191.6 \qquad 3 \times 130.7 \qquad 2 \times 192.5 \qquad \frac{J}{mol \cdot K}$

$\Delta S^\circ_{reaction}$ = Products - Reactants =

$[(2\ mol\ NH_3)(192.5\ \frac{J}{mol \cdot K})] -$

$[(1\ mol\ N_2)(191.6\ \frac{J}{mol \cdot K}) + (3\ mol\ H_2)(130.7\ \frac{J}{mol \cdot K})]$

$= -198.7\ J/K$

(A) $\Delta S^\circ_{reaction} = -198.7$ J/K
(B) $\Delta S^\circ_{reaction} = +514.8$ J/K
(C) $\Delta S^\circ_{reaction} = -514.8$ J/K
(D) $\Delta S^\circ_{reaction} = +966.9$ J/K
(E) $\Delta S^\circ_{reaction} = -775.3$ J/K

23. The solubility of PbI_2 ($K_{sp} = 8.7 \times 10^{-9}$) is:

(A) 2.9×10^{-4} M
(B) 1.3×10^{-3} M
(C) 4.6×10^{-5} M
(D) 2.1×10^{-3} M
(E) 8.7×10^{-4} M

$PbI_2(s) \rightleftharpoons Pb^{2+}(aq) + 2I^-(aq)$

$\qquad\qquad\qquad\quad x \qquad\quad 2x$

$K_{sp} = [Pb^{2+}][I^-]^2$

$8.7 \times 10^{-9} = (x)(2x)^2$

$\frac{8.7 \times 10^{-9}}{4} = \frac{4x^3}{4}$

$x^3 = 2.18 \times 10^{-9}$

$x = 1.30 \times 10^{-3}$

Solubility = 1.30×10^{-3} M

24. A student prepares a solution that is 2.7×10^{-6} M in $[Ba^{2+}]$ and 1.2×10^{-5} M in $[SO_4^{2-}]$. The K_{sp} of $BaSO_4$ is 1.1×10^{-10}.

(A) a solid will form from
(B) a solid will not form

$$BaSO_4(s) \rightleftarrows Ba^{2+}(aq) + SO_4^{2-}(aq)$$

$$Q = [Ba^{2+}][SO_4^{2-}]$$

$$Q = (2.7 \times 10^{-6})(1.2 \times 10^{-5})$$

$$Q = 3.24 \times 10^{-11}$$

Q less than K — a solid will not form

25. Because of Chemistry 123...

(A) I now understand *entropy* is responsible for the current state of my life.
(B) I have a blister the size of a Frisbee on my brain.
(C) My pick-up lines now include the words *titrate, conjugate, dissociate, and buffer system.*
(D) The thought of that forthcoming root canal no longer seems agonizing.
(E) It snowed and hailed all weekend long.

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