Chemistry 123 | Spring 2009 | Oregon State University
Exam 1 | April 23, 2009 | 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] $= 3.7 \times 10^{-8}$

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 0.315 M HNO_3 (aq) is: ← strong Acid

(A) 3.14
(B) 1.57
(C) 0.0269
(D) 0.288
(E) 0.502

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

0.315 M → 0.315 M, 0.315 M

$pH = -\log[H^+] = -\log(0.315) = 0.502$

2. The $[H^+]$ of 0.407 M $CH_2ClCOOH$ (aq) is: weak acid

(A) 0.150 M
(B) 0.0239 M
(C) 2.51 M
(D) 2.74 M
(E) 3.74 M

less than 100%

	$CH_2ClCOOH(aq) \rightleftharpoons$	$CH_2ClCOO^-(aq)$ +	$H^+(aq)$
I	0.407	∅	∅
C	−x	+x	+x
E	0.407 − x	x	x

$K_a = 1.40 \times 10^{-3} = \frac{\text{products}}{\text{reactants}} = \frac{[CH_2ClCOO^-][H^+]}{[CH_2ClCOOH]} = \frac{x^2}{0.407 - x}$ → out

$1.40 \times 10^{-3} = \frac{x^2}{0.407}$

$x = [H^+] = 0.0239$

If you had wanted the pH...
$pH = -\log[H^+] = -\log(0.0239)$
$= 1.62$

3. The pH of 0.330 M NH_3 (aq) is: weak base

(A) 0.0024
(B) 2.61
(C) 0.0269
(D) 0.288
(E) 11.4

	$NH_3(aq) + H_2O(l) \rightleftharpoons$	$NH_4^+(aq)$ +	$OH^-(aq)$
I	0.330	∅	∅
C	−x	+x	+x
E	0.330 − x	x	x

$K_b = 1.80 \times 10^{-5} = \frac{\text{products}}{\text{reactants}} = \frac{[NH_4^+][OH^-]}{[NH_3]} = \frac{x^2}{0.330 - x}$ → out

$1.80 \times 10^{-5} = \frac{x^2}{0.330}$

$x = [OH^-] = 0.00244$

$pOH = -\log[OH^-] = -\log(0.00244) = 2.61$

$pH + pOH = 14$

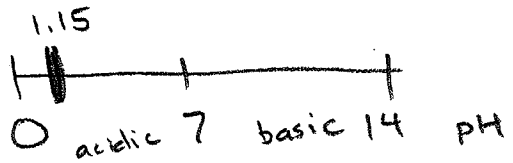
$pH = 14 - pOH$

$pH = 14 - 2.61 = 11.4$

4. A student measures the $[H^+]$ in an aqueous solution to be 7.0×10^{-2} M. This solution is:

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

$pH = -\log[H^+] = -\log(7.0 \times 10^{-2}\ M) = 1.15$



5. The pH of an aqueous system is measured to be 3.46. The $[OH^-]$ of this system is:

(A) 3.30×10^{-7} M
(B) 3.46×10^{-7} M
(C) 2.88×10^{-11} M
(D) 3.46×10^{-10} M
(E) 10.54 M

$pH = 3.46$

$pH + pOH = 14$

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

$[OH^-] = 10^{-pOH} = 10^{-10.54} = 2.88 \times 10^{-11}$ M

6. The pOH of 0.040 M HCl (aq) is: — strong Acid

(A) 10.0
(B) 4.00
(C) 1.40
(D) 12.6
(E) 26.5

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

0.040 0.040

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

$pH + pOH = 14$

$pOH = 14 - pH = 14 - 1.40 = 12.6$

7. The pH of a buffer system which is 0.120 M C_6H_5COOH (aq) and 0.120 M C_6H_5COONa (aq) is:

Acid — Base ← Same as $C_6H_5COO^-(aq)$ ← $Na^+(aq)$ is a spectator ion

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

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

0.120 M 0.120 M

$K_a = 6.30 \times 10^{-5} = \frac{[C_6H_5COO^-][H^+]}{[C_6H_5COOH]} = \frac{(0.120)[H^+]}{(0.120)}$

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

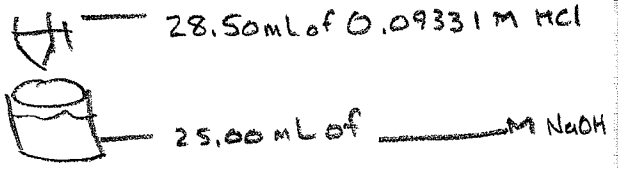
more acid than base

8. Which of the following three buffer systems has the **lowest** pH?

(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.

ACID BASE

9. A student titrates 25.00 mL of NaOH (aq) with 28.50 mL of 0.09331 M HCl (aq) to reach the equivalence point. The concentration of NaOH (aq) is:



(A) 9.401 M
(B) 6.706 M
(C) 0.1064 M
(D) 1.072×10^{-3} M
(E) 0.1064 M ← Both correct

$Moles_{Acid} = moles_{Base}$

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

$(0.09331\ M)(28.50\ mL) = (M_{Base})(25.00\ mL)$

$M_{Base} = 0.1064\ M$

10. A student titrates 0.5222 grams of KHP (potassium hydrogen phthalate; MW=204.2 g/mol) to the equivalence point with 24.08 mL of NaOH (aq). The concentration of the NaOH solution is:

(A) 0.09722 M
(B) 0.1722 M
(C) 0.1062 M
(D) 1.722×10^{-4} M
(E) 9.416 M

mL to L

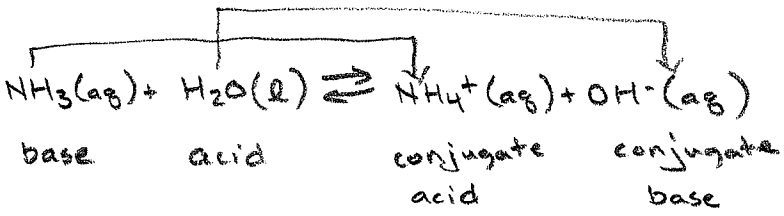
$\frac{\text{grams KHP}}{\text{MWT KHP}} = M_{NaOH}V_{NaOH}$

$\frac{0.5222\ g\ KHP}{204.2\ g/mol} = (M_{NaOH})(0.02408\ L)$

$M_{NaOH} = 0.1062\ M$

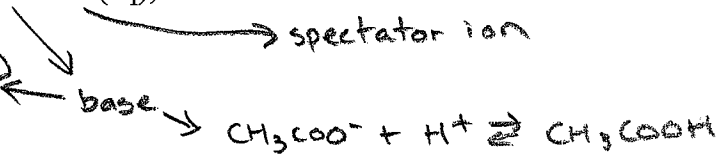
11. Consider the reaction of ammonia, NH_3, and water. The conjugate acid is:

(A) HCOOH
(B) NH_3
(C) NH_4^+
(D) H^+
(E) $HCOO^-$

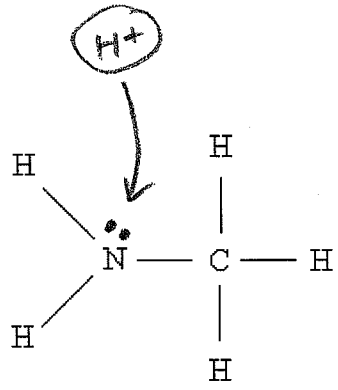


12. The pH of 0.300 M CH_3COONa (aq), is:

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



13. The compound:



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

Can accept a proton

$K_a \rightarrow$ 1.8×10^{-5} 1.40×10^{-3} 6.3×10^{-5} (largest K_a)

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

(A) CH_3COOH
(B) $CH_2ClCOOH$
(C) C_6H_5COOH

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

$\Delta G = \Delta H - T\Delta S$
(-) (-) (+)
↓ exothermic
↘ greater disorder

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

(A) Dissolving salt in a pot of water
(B) Opening up a bottle of perfume
(C) Rubbing alcohol evaporating off a table
(D) Steam from an iron condensing on your arm (g) → (l)
(E) Dry ice subliming during a concert for a thrilling effect

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

more disorder

(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) $N_2\ (l) \rightarrow N_2\ (g)$
(E) $2\ C_2H_2(g) + 5\ O_2(g) \rightarrow 4\ CO_2(g) + 2\ H_2O(g)$

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

more disorder

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

(+) 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.

19. $\Delta H = +88$ kJ and $\Delta S = +288$ J/K for a process. Determine the temperature in which the system is at equilibrium?

J to kJ

(A) 19.0 K
(B) 327 K
(C) 253 K
(D) 3273 K
(E) 306 K

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

$0 = 88\ kJ - (T)(.288\ \frac{kJ}{K})$

$T = 306\ K$

20. Consider the combustion of pentane: C_5H_{12} (g) + 8 O_2 (g) → 5 CO_2 (g) + 6 H_2O (g).

exothermic → ΔH(-)

9 mol (g) → 11 mol (g) ΔS = (+)

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

21. Consider a process in which K = 2.8×10^{-9}. ← small ΔG = (+) not spontaneous

The math supports this

(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

$\Delta G = -RT\ln K$
$= -(+)(+)(-)$
$= (+)$

22. 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

$\Delta S = \frac{q_{rev}}{T} = \frac{468\ kJ}{298\ K} = 1.57\ \frac{kJ}{K}$ or $1570\ \frac{J}{K}$

23. Determine ΔS for the reaction $2\ C_2H_4O\ (l) + 2\ H_2O\ (l) \rightarrow 2\ C_2H_6O\ (l) + O_2\ (g)$ using the following two reactions:

x2 (1) $2\ CO_2\ (g) + 3\ H_2O\ (l) \rightarrow C_2H_6O\ (l) + 3\ O_2\ (g)$ $\Delta S_1 = +371$ kJ

Flip x2 (2) $2\ CO_2\ (g) + 2\ H_2O\ (g) \rightarrow C_2H_4O\ (l) + 5/2 O_2\ (g)$ $\Delta S_2 = -1167$ kJ

$4\ CO_2 + 2\ H_2O \rightarrow 2\ C_2H_6O + 6\ O_2$ $\Delta S_1' = +371\ kJ \times 2$

$2\ C_2H_4O + 5\ O_2 \rightarrow 4\ CO_2 + 4\ H_2O$ $\Delta S_2' = +1167 \times 2$

$2\ C_2H_4O + 2\ H_2O \rightarrow 2\ C_2H_6O + 1\ O_2$ $\Delta S = 3076$ kJ

(A) - 796 kJ
(B) + 1538 kJ
(C) - 1592 kJ
(D) + 3076 kJ
(E) - 1963 kJ

24.

Formula	ΔH°_f (kJ/mol)	ΔG°_f (kJ/mol)	S° (J/mol•K)
C_3H_8 (g)	-103.8	-23.56	270.2
O_2 (g)	0	0	205.0
CO_2 (g)	-393.5	-394.4	213.6
H_2O (l)	-285.8	-237.2	69.91

C_3H_8 (g) + 5 O_2 (g) → 3 CO_2 (g) + 4 H_2O (l)

270.2 J/mol·K 205.0 J/mol·K 213.6 J/mol·K 69.91 J/mol·K

$\Delta S^\circ_{reaction}$ for the combustion of propane is:

(A) -374.8 J/K
(B) +393.5 J/K
(C) 0 J/K
(D) -393.5 J/K
(E) +374.8 J/K

ΔS°_{rxtn} = products − reactants

$= \{(3\,mol\,CO_2)(213.6\,J/mol\cdot K) + (4\,mol\,H_2O)(69.91\,J/mol\cdot K)\} -$

$\{(1\,mol\,C_3H_8)(270.2\,J/mol\cdot K) + (5\,mol)(205.0\,J/mol\cdot K)\} =$

$= -374.8\,J/K$

25. So, Exam 1 is over. And now…

(A) I'm goin' Party like it's 1999.
(B) Vegas.
(C) Sax. I'm going to a nightclub and play the saxophone with a band.
(D) I will be titrating some snacks.
(E) I will be laying out on the grass. Looking up at the sky. Trying to envision each cloud as a piece of chemistry glassware.
[Understand this... since this notion is in your psyche, every time you look at a cloud you will smile and see a Erlenmeyer Flask.]
[Any response will receive full credit; even no response.]