Printed Name:_____
Student Number: _____
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CHEMISTRY 1420 FOURTH EXAM 100 POINTS

Each multiple choice test question is worth 3 points. Read each question very carefully. There is no partial credit for the multiple choice test questions. The four numerical questions on the exam are worth 10 points each. On the four numerical questions (i.e., non-multiple choice questions) partial credit will be past upon the work shown. **NOTE: TO RECEIVE PARTIAL CREDIT FOR ANY NON-MULTIPLE CHOICE PROBLEM, THE WORK SHOWN MUST BE CONSISTENT WITH THE ANSWER GIVEN!!**

Question 1: Which of the following is not a conjugate acid-base pair?

(a) H_2CO_3/HCO_3^-

(b) NH_4^+/NH_3

(c) HS^-/S^{2-}

(d) H_3PO_4/HPO_4^{2-}

(e) All of the above are conjugate acid-base pairs

Question 2: Which of the solutions would represent a buffered solution?

(a) A solution prepared by dissolving 0.100 moles of H_3PO_4 and 0.100 moles of HCl in 1 liter of distilled water

(b) A solution prepared by dissolving 0.100 moles of H_3PO_4 and 0.100 moles of Na_2HPO_4 in 1 liter of distilled water

(c) A solution prepared by dissolving 0.100 moles of $HC_2H_3O_2$ and 0.100 moles of $NaC_2H_3O_2$ in 1 liter of distilled water

(d) A solution prepared by dissolving 0.100 moles of $NaC_2H_3O_2$ in 1 liter of distilled water

(e) None of the above are buffered solutions.

Question 3: Phosphoric acid, H_3PO_4, is a triprotic acid. Which of the following statements pertaining to the pH titration curve of H_3PO_4 with NaOH is correct?

(a) Halfway to the first equivalence point $[H_3O^+] = K_{a2}$

(b) Halfway between the first equivalence and second equivalence points $[H_3O^+] = K_{a1}$

(c) Halfway between the second equivalence and third equivalence points $[H_3O^+] = K_{a2}$

(d) Halfway between the second equivalence and third equivalence points $[H_3O^+] = K_{a3}$

(e) At the first equivalence point $[H_3O^+] = K_{a1}$

Question 4: The acid dissociation constants of H_3PO_4 are $K_{a1} = 7.5 \times 10^{-3}$ ($pK_{a1} = 2.12$); $K_{a2} = 6.2 \times 10^{-8}$ ($pK_{a2} = 7.21$); and $K_{a3} = 3.6 \times 10^{-15}$ ($pK_{a3} = 12.44$). Which of the following sets of chemicals would be needed to prepare a buffered solution having a pH = 7.21?

(a) Only H_3PO_4

(b) Both H_3PO_4 and NaH_2PO_4

(c) Both NaH_2PO_4 and Na_2HPO_4

(d) Both Na_2HPO_4 and Na_3PO_4

(e) Only Na_3PO_4

Question 5: Which of the following statements pertaining to buffers is not true?

(a) Buffers usually consist of approximately equal quantities of a weak acid and its conjugate base, or a weak base and its conjugate acid

(b) A Buffer is a chemical system that resists changes in pH when a limited amount of base is added to it.

(c) A Buffer is a chemical system that resists changes in pH when a limited amount of acid is added to it.

(d) A Buffer is a chemical system that resists changes in pH when the solution volume is increased modestly.

(e) A Buffer is prepared by dissolving only the sodium salt of a weak acid in distilled water.

Question 6: What is the balanced chemical reaction corresponding to the second equivalence point in the titration of H_3PO_4 with NaOH

(a) $H_3PO_{4(aq)} + NaOH_{(aq)}$ --------> $Na_2HPO_{4(aq)} + 2\ H_2O$

(b) $2\ H_3PO_{4(aq)} + NaOH_{(aq)}$ --------> $Na_2HPO_{4(aq)} + 2\ H_2O$

(c) $H_3PO_{4(aq)} + 2\ NaOH_{(aq)}$ --------> $Na_2HPO_{4(aq)} + 2\ H_2O$

(d) $H_3PO_{4(aq)} + NaOH_{(aq)}$ --------> $NaH_2PO_{4(aq)} + H_2O$

(e) $H_3PO_{4(aq)} + 3\ NaOH_{(aq)}$ --------> $Na_3PO_{4(aq)} + 3\ H_2O$

Question 7: Which of the following expressions corresponds to the Henderson-Hasselbalch equation?

(a) $pH = pK_a - \log \frac{[conjugate\ base]}{[conjugate\ acid]}$

(b) $pH = \frac{pK_{a1} + pK_{a2}}{2}$

(c) $pK_a = -\log K_a$

(d) $pH = pK_a + \log \frac{[conjugate\ base]}{[conjugate\ acid]}$

(e) None of the above equations are correct

Question 8: How many moles of acetic acid, $HC_2H_3O_2$, remain unreacted whenever 10 mls of 0.100 Molar NaOH is added to 50 mls of 0.100 Molar $HC_2H_3O_2$?

(a) 0.00400 moles

(b) 0.0667 moles

(c) 0.00300 moles

(d) 0.075 moles

(e) None of the above answers are correct

Question 9: Which of the following equations correspond to the solubility product, K_{sp}, of Ag_3PO_4 ?

(a) $K_{sp} = [Ag_3^{3+}][PO_4^{3-}]$

(b) $K_{sp} = [Ag^+]^3\,[PO_4^{3-}]$

(c) $K_{sp} = [Ag^+]^3\,[P^{+5}]\,[O^{2-}]^4$

(d) $Ksp = \frac{[Ag^+]^3[PO_4^{3-}]}{[Ag_3PO_4]}$

(e) None of the above answers are correct

Question 10: Which of the following statements pertaining to entropy is not true ?

(a) Entropy usually increases when a pure liquid or solid dissolves in a solvent

(b) Entropies of ionic solids that have similar formulas are smaller when the attractions among the ions are weaker

(c) Entropy decreases when a gas dissolves in a solid

(d) Entropies of gases are usually much larger than those of liquids

(e) Entropies of liquids are usually larger than those of solids

Question 11: For which of the following processes with entropy not increase ?

(a) $MgCO_{3(solid)}$ -------> $MgO_{(solid)} + CO_{2(gas)}$

(b) $2\ CO_{2(gas)}$ --------> $2\ CO_{(gas)} + O_{2(gas)}$

(c) $H_2O_{(solid)}$ ---------> $H_2O_{(gas)}$

(d) $H_{2(gas)} + O_2(gas)$ ----------> $H_2O_2(gas)$

(e) 1 mole of H_2 gas in 1 liter ----------> 1 mole of H_2 gas in 2 liters

Question 12: A process or reaction must always be spontaneous for which of the following sets of thermodynamic changes?

(a) ΔH° is negative and ΔS° is negative

(b) ΔH° is negative and ΔS° is positive

(c) ΔH° is positive and ΔS° is negative

(d) ΔH° is positive and ΔS° is positive

(e) ΔG° is positive

Question 13: For which of the following chemicals
$H_{2(gas)}$, $H_2O(liq)$, $H^-_{(aq)}$, $O_{2(gas)}$

is the standard Gibbs energy of formation, ΔG_f° not equal to zero?

(a) Both $H_{2(gas)}$ and $O_{2(gas)}$

(b) Only $H_2O_{(liq)}$

(c) Both $H_2O_{(liq)}$ and $H^+_{(aq)}$

(d) Only $H^-_{(aq)}$

(e) None of the above answers are correct

Question 14: What is the numerical value of the equilibrium constant at 25 °C for the equilibrium:

$N_{2(gas)} + O_{2(gas)}$ <----------> $2\,NO_{(gas)}$

$\Delta H^\circ = 180.5$ kJ and $\Delta S^\circ = 24.772$ J/K

(a) 18.30

(b) 0.0547

(c) 1.799×10^{5}

(d) 1.799×10^{-5}

(e) 4.679×10^{-31}

Question 15: What is the ΔG° at 25 °C for a reaction having an equilibrium constant of $K_c = 3.5 \times 10^{-8}$?

(a) 42.56 kJ

(b) -42.56 kJ

(c) -3.57 kJ

(d) 3.57 kJ

(e) 420 J

Question 16: The second law of thermodynamics states:

(a) That energy cannot be created nor destroyed – that is the total energy of the universe is constant

(b) That in an ordinary chemical reaction, one cannot create nor destroy matter

(c) That the total entropy of the universe (a system plus surroundings) is continually increasing

(d) That all exothermic reactions must be spontaneous

(e) That if the equation for a reaction is the sum of the equations for two or more other reactions, then ΔH° for the first reaction must equal the sum of the ΔH° values of the other reactions.

Question 17: The solubility product of AgCl is $K_{sp} = 1.8 \times 10^{-10}$. What is the solubility of AgCl in distilled water?

(a) 1.8×10^{-10} molar

(b) 1.34×10^{-5} molar

(c) 9.74 molar

(d) 5.56×10^{-5} molar

(e) 2.68×10^{-5} molar

Question 18: The solubility product of AgCl is $K_{sp} = 1.8 \times 10^{-10}$. What is the solubility of AgCl in an aqueous 0.010 Molar $CaCl_2$ solution? (Calcium chloride is a strong electrolyte.)

(a) 9.0×10^{-9}

(b) 1.8×10^{-8}

(c) 5.65×10^{-4}

(d) 5.65×10^{-6}

(e) 1.34×10^{-5}

Question 19: What would be the change in entropy in the surroundings for the following chemical reaction:

$CO_{(gas)} + 2\ H_{2(gas)}$ ---------> $CH_4OH_{(liq)} + 128.1$ kJ

if the reaction were to occur at 25 °C ? The $\Delta H^\circ = -128.1$ kJ (exothermic) as indicated above

(a) 0.430 kJ/K

(b) -0.430 kJ/K

(c) 5.124 kJ/K

(d) -5.124 kJ/K

(e) -128.1 kJ

Question 20: At what temperature would the reaction:

$2\ Ag_2O_{(solid)}$ ----------> $4\ Ag_{(solid)} + O_{2(gas)}$

Switch from being reactant-favored to product-favored? Assume that both ΔH° and ΔS° do not depend on temperature. Information given is $\Delta H^\circ = 62.1$ kJ and $\Delta S^\circ = 132.71$ J/K

(a) 273.61 K

(b) 467.9 K

(c) 2137.0 K

(d) 667.9 K

(e) Cannot be calculated with the information given

NUMERICAL (NON-MULTIPLE CHOICE) QUESTIONS: Each numerical question is worth 10 points. Remember partial credit is based on the work shown. and to receive partial credit the work must be consistent with the answer shown.

Question 21: (10 Points)

What is the solubility of Ag_2CrO_4 ($K_{sp} = 9.0 \times 10^{-12}$) in distilled water?

Question 22 (10 Points)

Show by calculation whether AgCl ($K_{sp} = 1.8 \times 10^{-10}$) or Ag_2CrO_4 ($K_{sp} = 9.0 \times 10^{-12}$) would precipitate first if one were to slowly add Ag^+ ions to a solution containing 0.020 Molar Cl^- and 0.01 Molar CrO_4^{2-}.

Question 23 (10 Points)

Calculate the ΔG^{o} at 298.15 K for the reaction

$$C_3H_{8(gas)} + 5\ O_{2(gas)} \text{ ---------> } 3\ CO_{2(gas)} + 4\ H_2O_{(gas)}$$

Given the following standard Gibbs energies of formation at 298.15:

For

$C_3H_{8(gas)}$: $\Delta G_{f,298.15K}^{o} = -23.49$ kJ/mole

$CO_{2(gas)}$: $\Delta G_{f,298.15K}^{o} = -623.08$ kJ/mole

$H_2O_{(gas)}$: $\Delta G_{f,298.15K}^{o} = -228.57$ kJ/mole

$H_2O_{(liq)}$: $\Delta G_{f,298.15K}^{o} = -237.13$ kJ/mole

Question 24 (10 Points)

Calculate the equilibrium constant for a reaction having a value of $\Delta G^{\circ} = -10.32$ kJ at 298.15 K

IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1 H 1.01																	2 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 23.00	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 51.97	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 *La 138.91	72 Hf 178.49	73 Ta 180.94	74 W 183.85	75 Re 186.21	76 Os 190.20	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.20	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.03	89 †Ac 227.03	104 Unq§ (261)	105 Unp§ (262)	106 Unh§ (263)												

* Lanthanides

58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97

† Actinides

90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)