

Printed Name: \_\_\_\_\_

Student Number: \_\_\_\_\_

Signature: \_\_\_\_\_

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)  $\text{H}_2\text{CO}_3/\text{HCO}_3^-$
- (b)  $\text{NH}_4^+/\text{NH}_3$
- (c)  $\text{HS}^-/\text{S}^{2-}$
- (d)  $\text{H}_3\text{PO}_4/\text{HPO}_4^{2-}$
- (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  $\text{H}_3\text{PO}_4$  and 0.100 moles of HCl in 1 liter of distilled water
- (b) A solution prepared by dissolving 0.100 moles of  $\text{H}_3\text{PO}_4$  and 0.100 moles of  $\text{Na}_2\text{HPO}_4$  in 1 liter of distilled water
- (c) A solution prepared by dissolving 0.100 moles of  $\text{HC}_2\text{H}_3\text{O}_2$  and 0.100 moles of  $\text{NaC}_2\text{H}_3\text{O}_2$  in 1 liter of distilled water
- (d) A solution prepared by dissolving 0.100 moles of  $\text{NaC}_2\text{H}_3\text{O}_2$  in 1 liter of distilled water
- (e) None of the above are buffered solutions.

Question 3: Phosphoric acid,  $\text{H}_3\text{PO}_4$ , is a triprotic acid. Which of the following statements pertaining to the pH titration curve of  $\text{H}_3\text{PO}_4$  with NaOH is correct?

- (a) Halfway to the first equivalence point  $[\text{H}_3\text{O}^+] = K_{a2}$
- (b) Halfway between the first equivalence and second equivalence points  $[\text{H}_3\text{O}^+] = K_{a1}$
- (c) Halfway between the second equivalence and third equivalence points  $[\text{H}_3\text{O}^+] = K_{a2}$

- (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  $K_{a3} = 3.6 \times 10^{-13}$  ( $pK_{a3} = 12.44$ ). 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)  $H_3PO_{4(aq)} + NaOH_{(aq)} \rightarrow Na_2HPO_{4(aq)} + 2 H_2O$
- (b)  $2 H_3PO_{4(aq)} + NaOH_{(aq)} \rightarrow Na_2HPO_{4(aq)} + 2 H_2O$
- (c)  $H_3PO_{4(aq)} + 2 NaOH_{(aq)} \rightarrow Na_2HPO_{4(aq)} + 2 H_2O$
- (d)  $H_3PO_{4(aq)} + NaOH_{(aq)} \rightarrow NaH_2PO_{4(aq)} + H_2O$
- (e)  $H_3PO_{4(aq)} + 3 NaOH_{(aq)} \rightarrow Na_3PO_{4(aq)} + 3 H_2O$

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)  $K_{sp} = \frac{[Ag^+]^3 [PO_4^{3-}]}{[Ag_3PO_4]}$

(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

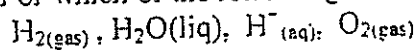
Question 11: For which of the following processes with entropy not increase ?

- (a)  $\text{MgCO}_3(\text{solid}) \rightarrow \text{MgO}(\text{solid}) + \text{CO}_2(\text{gas})$
- (b)  $2 \text{CO}_2(\text{gas}) \rightarrow 2 \text{CO}(\text{gas}) + \text{O}_2(\text{gas})$
- (c)  $\text{H}_2\text{O}(\text{solid}) \rightarrow \text{H}_2\text{O}(\text{gas})$
- (d)  $\text{H}_2(\text{gas}) + \text{O}_2(\text{gas}) \rightarrow \text{H}_2\text{O}_2(\text{gas})$
- (e) 1 mole of  $\text{H}_2$  gas in 1 liter  $\rightarrow$  1 mole of  $\text{H}_2$  gas in 2 liters

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

- (a)  $\Delta H^\circ$  is negative and  $\Delta S^\circ$  is negative
- (b)  $\Delta H^\circ$  is negative and  $\Delta S^\circ$  is positive
- (c)  $\Delta H^\circ$  is positive and  $\Delta S^\circ$  is negative
- (d)  $\Delta H^\circ$  is positive and  $\Delta S^\circ$  is positive
- (e)  $\Delta G^\circ$  is positive

Question 13: For which of the following chemicals

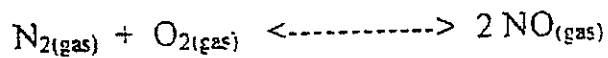


is the standard Gibbs energy of formation,  $\Delta G_f^\circ$  not equal to zero?

- (a) Both  $\text{H}_2(\text{gas})$  and  $\text{O}_2(\text{gas})$
- (b) Only  $\text{H}_2\text{O}(\text{liq})$
- (c) Both  $\text{H}_2\text{O}(\text{liq})$  and  $\text{H}^-(\text{aq})$
- (d) Only  $\text{H}^-(\text{aq})$

- (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:



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

- (a) 18.30  
(b) 0.0547  
(c)  $1.799 \times 10^5$   
(d)  $1.799 \times 10^{-5}$   
(e)  $4.679 \times 10^{-31}$

Question 15: What is the  $\Delta G^\circ$  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  $\Delta H^\circ$  for the first reaction must equal the sum of the  $\Delta H^\circ$  values of the other reactions.

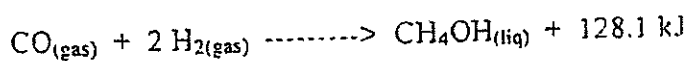
Question 17: The solubility product of AgCl is  $K_{sp} = 1.8 \times 10^{-10}$ . What is the solubility of AgCl in distilled water?

- (a)  $1.8 \times 10^{-10}$  molar
- (b)  $1.34 \times 10^{-5}$  molar
- (c) 9.74 molar
- (d)  $5.56 \times 10^{-5}$  molar
- (e)  $2.68 \times 10^{-5}$  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  $\text{CaCl}_2$  solution? (Calcium chloride is a strong electrolyte.)

- (a)  $9.0 \times 10^{-9}$
- (b)  $1.8 \times 10^{-8}$
- (c)  $5.65 \times 10^{-4}$
- (d)  $5.65 \times 10^{-6}$
- (e)  $1.34 \times 10^{-5}$

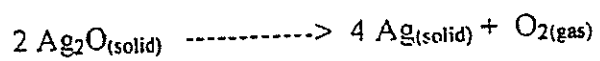
Question 19: What would be the change in entropy in the surroundings for the following chemical reaction:



if the reaction were to occur at 25 °C? The  $\Delta H^\circ = -128.1 \text{ kJ}$  (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:



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

- (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  $\text{Ag}_2\text{CrO}_4$  ( $K_{sp} = 9.0 \times 10^{-12}$ ) in distilled water?

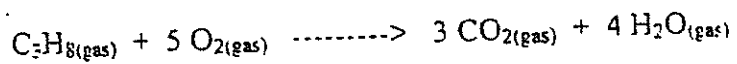


Question 22 (10 Points)

Show by calculation whether  $\text{AgCl}$  ( $K_{sp} = 1.8 \times 10^{-10}$ ) or  $\text{Ag}_2\text{CrO}_4$  ( $K_{sp} = 9.0 \times 10^{-12}$ ) would precipitate first if one were to slowly add  $\text{Ag}^+$  ions to a solution containing 0.020 Molar  $\text{Cl}^-$  and 0.01 Molar  $\text{CrO}_4^{2-}$ .

Question 23 (10 Points)

Calculate the  $\Delta G^\circ$  at 298.15 K for the reaction



Given the following standard Gibbs energies of formation at 298.15:

For

$\text{C}_3\text{H}_8(\text{gas})$	: $\Delta G_{f,298.15\text{K}}^\circ = -23.49 \text{ kJ/mole}$
$\text{CO}_2(\text{gas})$	: $\Delta G_{f,298.15\text{K}}^\circ = -623.08 \text{ kJ/mole}$
$\text{H}_2\text{O}(\text{gas})$	: $\Delta G_{f,298.15\text{K}}^\circ = -228.57 \text{ kJ/mole}$
$\text{H}_2\text{O}(\text{liq})$	: $\Delta G_{f,298.15\text{K}}^\circ = -237.13 \text{ kJ/mole}$

Question 24 (10 Points)

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

VIIA

2	He	4.00					VIIA
10	Ne	20.18					VIIA
9	F	19.00					VIIA
8	O	16.00					VIIA
7	N	14.01					VIIA
6	C	12.01					VIIA
5	B	10.81					VIIA
18	Ar	39.95					VIIA
17	Cl	35.45					VIIA
16	S	32.06					VIIA
36	Kr	83.80					VIIA
35	Br	79.90					VIIA
54	Xe	131.29					VIIA
53	I	126.90					VIIA
86	Rn	(222)					VIIA
85	At	(210)					VIIA
84	Po	(209)					VIIA
83	Bi	208.98					VIIA
82	Pb	207.20					VIIA
81	Tl	204.38					VIIA
49	In	114.82					VIIA
50	Sn	118.69					VIIA
51	Sb	121.75					VIIA
52	Te	127.60					VIIA
33	As	74.92					VIIA
34	Se	78.96					VIIA
32	Ge	72.59					VIIA
31	Ga	69.72					VIIA
14	Si	28.09					VIIA
13	Al	26.98					VIIA

1	H	1.01																	IA
4	He	4.01																	IIA
11	Na	23.00																	IIA
12	Mg	24.31																	IIA
19	K	39.10																	IIA
20	Ca	40.08																	IIA
37	Rb	85.47																	IIA
38	Sr	87.62																	IIA
55	Cs	132.91																	IIA
56	Ba	137.33																	IIA
87	Fr	(223)																	IIA
88	Ra	(226)																	IIA
89	Ac	(227)																	IIA
104	Uup	(261)																	IIA
105	Uuq	(262)																	IIA
106	Uub	(263)																	IIA
74	W	183.85																	VIIB
75	Re	186.21																	VIIB
76	Os	190.20																	VIIB
77	Ir	192.22																	VIIB
78	Pt	195.08																	VIIB
79	Au	196.97																	VIIB
80	Hg	200.59																	VIIB
47	Ag	107.87																	VIIB
48	Cd	112.41																	VIIB
49	In	114.82																	VIIB
50	Sn	118.69																	VIIB
51	Sb	121.75																	VIIB
52	Te	127.60																	VIIB
53	I	126.90																	VIIB
54	Xe	131.29																	VIIB
81	Tl	204.38																	VIIB
82	Pb	207.20																	VIIB
83	Bi	208.98																	VIIB
84	Po	(209)																	VIIB
85	At	(210)																	VIIB
86	Rn	(222)																	VIIB
29	Cu	63.55																	IB
30	Zn	65.38																	IB
28	Ni	58.69																	IB
27	Co	58.93																	IB
26	Fe	55.85																	IB
44	Rn	101.07																	IB
45	Rh	102.91																	IB
46	Pd	106.42																	IB
47	Ag	107.87																	IB
48	Cd	112.41																	IB
25	Mn	54.94																	VIIIB
26	Fe	55.85																	VIIIB
27	Co	58.93																	VIIIB
28	Ni	58.69																	VIIIB
29	Cu	63.55																	VIIIB
30	Zn	65.38																	VIIIB
43	Tc	(98)																	VIIIB
44	Ru	101.07																	VIIIB
45	Rh	102.91																	VIIIB
46	Pd	106.42																	VIIIB
47	Ag	107.87																	VIIIB
48	Cd	112.41																	VIIIB
73	Ta	180.94																	VIB
74	W	183.85																	VIB
75	Re	186.21																	VIB
76	Os	190.20																	VIB
77	Ir	192.22																	VIB
78	Pt	195.08																	VIB
79	Au	196.97																	VIB
80	Hg	200.59																	VIB
41	Nb	92.91																	VIB
42	Mo	95.94																	VIB
43	Tc	(98)																	VIB
44	Ru	101.07																	VIB
45	Rh	102.91																	VIB
46	Pd	106.42																	VIB
47	Ag	107.87																	VIB
48	Cd	112.41																	VIB
23	V	50.94																	VB
24	Cr	51.97																	VB
41	Nb	92.91																	VB
42	Mo	95.94																	VB
22	Ti	47.88																	IVB
23	V	50.94																	IVB
40	Zr	91.22																	IVB
41	Nb	92.91																	IVB
72	Hf	178.49																	IVB
73	Ta	180.94																	IVB
74	W	183.85																	IVB
75	Re	186.21																	IVB
76	Os	190.20																	IVB
77	Ir	192.22																	IVB
78	Pt	195.08																	IVB
79	Au	196.97																	IVB
80	Hg	200.59																	IVB
21	Sc	44.96																	IIIB
22	Ti	47.88																	IIIB
39	Y	88.91																	IIIB
57	La	138.91																	IIIB
89	Ac	227.03																	IIIB
21	Sc	44.96																	IIIB
22	Ti	47.88																	IIIB
39	Y	88.91																	IIIB
57	La	138.91																	IIIB
89	Ac	227.03																	IIIB

\* 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
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† 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)
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