Chemistry 2 Final Exam Spring 2012

Name _____

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Before you begin the exam, write your name on this page, on page 3.

WARNING: There are questions on BOTH sides of most pages.

There are **200 points** on this exam. Your final-exam grade will be found by dividing your point total by 2.

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You have **2 hours and 15 minutes**. Do not spend too much time on one question.

This exam has 15 pages and 8 sheets. Make sure you have all of them.

Use of cell phones is forbidden and will be considered as cheating.

IA	IIA											IIIA	IVA	VA	VIA	VIIA	0
1 H 1.0079																1 H 1.0079	2 He 4.0026
3 Li 6.941	4 Be 9.0122											5 B 10.81	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.179
11 Na 22.989	12 Mg 24.305											13 Al 26.981	14 Si 28.086	15 P 30.974	16 S 32.06	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.08	21 Sc 44.956	22 Ti 47.88	23 V 50.941	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.69	29 Cu 63.546	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.22	41 Nb 92.905	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 138.90	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.2	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.0	89 # Ac 227.03															

* 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 158.92	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 232.03	91 Pa 231.03	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 (254)	100 Fm (257)	101 Md (257)	102 No (255)	103 Lr (256)

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$c = 3.00 \times 10^8$ m/s $\qquad F = 96,485$ C/mol

$R = 0.08206$ L atm/mol-K $= 8.314$ J/mol-K

NAME_____

1. (4 pts) (a) Give the formula of the conjugate base of HPO_4^{2-}.

(b) Give the formula of the conjugate acid of HPO_4^{2-}.

2. (10 pts) True or false? Write your answers as "True" or "False", not T or F.

(a) The rate law for the reaction A + 2B → products **must** be rate = $k[A][B]^2$.

(b) When a nucleus emits a gamma ray, its atomic number does not change and its mass number does not change.

(c) Two different isotopes of C must have the same number of protons and different numbers of nucleons.

(d) Reactions with a very high activation energy will be fast.

(e) In an oxidation-reduction reaction, one equivalent of the oxidizing agent always reacts with one equivalent of the reducing agent.

3. (2 pts) For $[Cr(NH_3)_2(en)_2]Cl_3$

(a) give the oxidation number of Cr

(b) give the coordination number of Cr

4. (2 pts) Fats (lipids) are (a) ketones (b) amines (c) alcohols (d) esters (e) amides

5 . (3 pts.) Give the formula of the compound

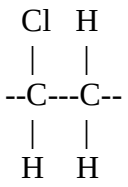
calcium triaquabromodicyanoferrate(II) (*Hint:* "ferrate" could also be written as "ironate".)

6. (3 pts) When HCl(aq) is titrated with NH_3(aq), the pH at the equivalence point is

(a) less than 7.0 (b) equal to 7.0 (c) greater than 7.0.

EXAM continued on the back

7. (3 pts) A portion of a polymer contains the following structure:



Write the structural formula (showing all bonds) of the monomer molecule that produced this polymer.

8. (3 pts) When HNO_3 is added to HCN(aq), the CN^- concentration is

(a) increased (b) decreased (c) not changed

Assume the addition of the HNO_3 does not change the volume of the solution.

9. (3 pts) For the reaction A $\rightarrow$ products, the following data were obtained:

experiment	initial [A]	initial rate
1	0.60	27 M min^{-1}
2	0.20	3.0 M min^{-1}

What is the order with respect to A?

10. (6 pts) For each of the following processes, state whether nuclear fission, nuclear fusion, or neither fission nor fusion is occurring:

(a) production of energy in the interior of the sun

(b) burning of gasoline

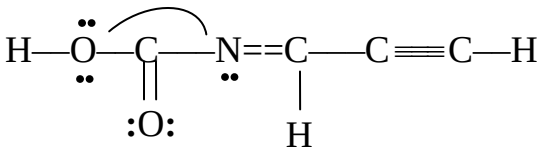
(c) explosion of the atomic bomb at Hiroshima in 1945

(d) production of electricity at the Indian point nuclear power plant

11. (2 points) If a solution absorbs only green light, what color will it appear to be?

12. (2 pts) An atom in a certain compound uses sp^2 hybrid orbitals. How many sp^2 hybrid orbitals are there on that atom?

13. (8 pts) In the molecule



(a) Give the value of the bond angle labeled A (angle OCN).

(b) Give the hybridization at the oxygen atom that is bonded to H.

(c) Give the hybridization at the carbon atom that is bonded to two other carbon atoms.

(d) How many π (pi) bonds are there in this molecule?

14. (3 pts) If a reaction has $\Delta G°$ less than zero, then the equilibrium constant will be

(a) Negative

(b) Less than 1 but greater than zero.

(c) Greater than 1

(d) This question is stupid because $\Delta G°$ can never be negative.

15. (6 pts) Complete and balance these reactions

(a) $C_7H_{16} + O_2 \rightarrow$

(b) $CH_3CH_2OH + CH_3\text{–}\overset{\overset{O}{\|}}{C}\text{–}OH \rightarrow$

(add a double bond to the three oxygens in (b) and (c) that are above a C)

(c) $H_2NCH_2\text{–}\overset{\overset{O}{\|}}{C}\text{–}OH + H_2NCH_2\text{–}\overset{\overset{O}{\|}}{C}\text{–}OH \rightarrow$

Exam continued on the back

16. (3 pts) The reaction in 15(c) is the first step in the formation of

(a) DNA (b) a fat (c) a protein (d) a carbohydrate

17. (3 pts) Which of the following will change the value of K_a for the weak acid HCN:

(a) changing the HCN concentration

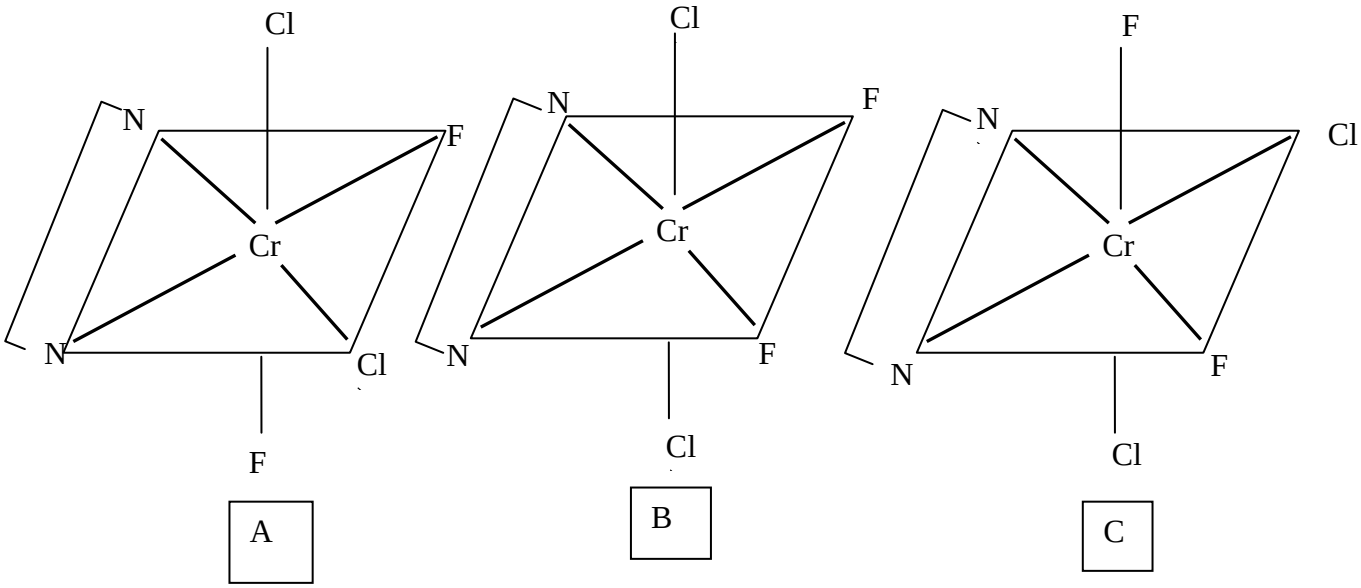
(b) changing the temperature

(c) both of (a) and (b)

(d) neither of (a) and (b)

18. (3 pts) A student carries out a reaction in which the ion MnO_4^- is reduced to MnO_2. The student uses a 0.60 M $KMnO_4$ solution. Find the normality of this solution.

19. (6 pts.) Consider these drawings, which are labeled A, B, and C



Answer each of the following questions by giving the letters of two drawings. If there is more than one way to answer the question, give only one pair of letters. If there is no way to answer the question, write "none".

(i) Give the letters of two drawings that are cis-trans (geometrical) isomers of each other.

(ii) Give the letters of two drawings that show the <u>same</u> molecule.

20. (4 pts) (a) The dashed line represents a mirror that is perpendicular to the plane of the paper. On the right side of the dashed line, show the mirror image of the molecule on the left by adding atoms. .

(b) Is the mirror image superimposable on the original molecule?

21. (3 pts) Which choice is completely true for the following molecules labeled A, B, C, and D? (Drawings are missing, but the molecules A and B are cis 1,2-difluoroethylene (CHFCHF) and trans 1,2-difluoroethylene; the molecules C and D are 1,2-difluoroethane (CH2FCH2F) with the two F atoms near each other and 1,2-difluorethane (CH2FCH2F) with the two F atoms far from each other).

(a) Molecule A is the same molecule as B. Molecule C is the same molecule as D

(b) A is the same as B. C is different than D.

(c) A is different than B. C is the same as D.

(d) A is different than B. C is different than D.

22.(5 pts) The Nernst equation is $E = E° - \frac{0.059\ \text{V}}{n} \log Q$. Zn is more active than Ag.

For a galvanic cell with the cell reaction $Zn(s) + 2Ag^+(aq) \rightarrow Zn^{2+}(aq) + 2Ag(s)$, if we increase the $Zn^{2+}(aq)$ concentration around the Zn electrode, then

(a) $E°$ of this cell will (increase, decrease, stay the same). (Circle the correct one of the three choices.

(b) E of this cell will (increase, decrease, stay the same). (Circle the correct choice.)

(c) Give the value of *n* for this cell.

Continued on the back

Reminder: This exam has 200 points. The total number of points for questions 1–22 is 86, which is 43% of the exam.

For Questions 23–42 . Show all work. You are not allowed to use the Henderson-Hasselbalch equation. See constants on page 3.

23. (6 pts) The half-life of ^{239}Pu is 2.4×10^4 years. A sample contains 34.2 g of ^{239}Pu. After 9500 years have gone by, what mass of ^{239}Pu will remain in the sample?

Formulas: $\ln(N_t/N_0) = -kt$ and $kt_{½} = 0.693$.

24. (6 pts) Find $[H^+]$ in a 25°C solution prepared by dissolving 0.20 moles of NH_4Cl in water and diluting to a volume of 400 mL, given that $K_b = 1.8 \times 10^{-5}$ for $NH_3(aq)$ at 25°C.

25. (6 pts) If 200 mL of 0.300 M $Cr(NO_3)_3(aq)$ is added to 100 mL of 4.0×10^{-4} M NaF(aq) at 25°C, will a CrF_3 precipitate form? You **must** show you calculations to get credit. For CrF_3 in water at 25°C, $K_{sp} = 6.6 \times 10^{-11}$.

26. (4 pts) Find the hydrogen-ion concentration of a 0.010 M $Ba(OH)_2(aq)$ solution at 25°C.

27. (4 pts) Find $[H^+]$ and $[OH^-]$ in pure water at 50°C given that $K_w = 5.5 \times 10^{-14}$ for H_2O at 50°C. Begin by writing the equilibrium reaction for the ionization of water.

28. (6 pts) Write nuclear reactions for the following processes:

(a) $^{242}_{94}Pu$ emits an alpha particle (a ^{4}He nucleus).

(b) $^{7}_{4}Be$ undergoes electron capture.

(c) $^{15}_{8}O$ emits a positron.

Continued on the back

29. (6 pts) A reaction has the mechanism

$$Cl + O_3 \rightarrow ClO + O_2$$

$$ClO + O \rightarrow Cl + O_2$$

(a) Write the overall reaction.

(b) Give the letters of all substances that are reaction intermediates.

(c) Give the letters of all substances that are catalysts in this reaction.

Your answers to (b) and (c) might be one, two, or no substances.

30. (5 pts) The activity of a sample of the radioactive isotope X decreases from 1200 disintegrations per minute to 150 disintegrations per minute after 120 days have passed. Find the half-life of X **without** using the formula $\ln(N_t/N_0) = -kt$. Give your reasoning.

31. (6 pts) Find $[H^+]$ in an aqueous 25°C solution that is 0.20 M in $HC_2H_3O_2$ and 0.48 M in $NaC_2H_3O_2$. For $HC_2H_3O_2$, $K_a = 1.8 \times 10^{-5}$ at 25°C.

32. (6 pts) Find the equilibrium constant at 25°C for the reaction

$$N_2O_4(g) \rightarrow 2NO_2(g)$$

given the following data at 25°C:

	ΔH_f°	ΔG_f°	S°
$NO_2(g)$	33.8 kJ/mol	51.8 kJ/mol	240.4 J/mol-K
$N_2O_4(g)$	9.7 kJ/mol	98.3 kJ/mol	304.3 J/mol-K

There is more than one way to do this problem. Do it the <u>faster</u> way so as to save time.

33. (4 pts) A cell that consists of an Ni, $NiSO_4(aq)$ half-cell, an Al, $AlCl_3(aq)$ half-cell, and a salt bridge. For $Ni^{2+}(aq) + 2e^- \rightarrow Ni$ at 25°C, E° = –0.28 V. For $Al^{3+}(aq) + 3e^- \rightarrow Al$ at 25°C, E° = –1.66 V.

(a) Write the spontaneous **net ionic** cell reaction.

(b) Find E° for this cell at 25°C.

34. (9 pts) Draw the structural formula of each of the following. Your structural formulas must show all the hydrogen atoms and must show all the bonds. (Do not give the condensed structural formula.) Your answer must not contain the letter R.

(a) An amine with two carbon atoms.

Continued on the back

(b) An ether with two carbon atoms.

(c) A carboxylic acid with two carbon atoms.

35. (3 pts) Draw the structural formula of 3-ethyl-2-methlyhexane.. Show all H atoms.

36. (3 pts) Balance the following **<u>half</u>**-reaction in **acidic** aqueous solution (note the charges):

$$I_2O_7 \rightarrow IO_2^-$$ (note the charge)

37. (6 pts) Consider the complex ion $[Mn(H_2O)_6]^{2+}$. Draw the crystal-field energy-level diagram and use arrows (that point up or down) to show the placement of d electrons assuming that this is

(a) a weak-field complex ion.

(b) a strong-field complex ion.

38. (3 pts) The $3d_{xy}$ orbital has its high probability regions lying between the x and y axes. The $3d_{z^2}$ orbital has its high probability regions mainly on the z axis. The ligands in a complex ion with coordination number six lie on the x, y, and z axes. Which statement is true for the orbitals in this complex ion?

(a) The $3d_{xy}$ and $3d_{z^2}$ orbitals have the same energy.

(b) The $3d_{xy}$ orbital has a higher energy than the $3d_{z^2}$ orbital.

(c) The $3d_{xy}$ orbital has a lower energy than the $3d_{z^2}$ orbital.

39. (6 pts) Draw <u>structural</u> formulas (showing all H atoms and all bonds) for <u>all</u> compounds with the formula C_5H_{12}.

40. (5 pts) Grace in the stockroom dissolves 0.25 moles of the acid HA in water and dilutes the solution to a final volume of 500 mL Grace gives a small portion of this solution to a Chem 2100 student named Fred. Fred uses a pH meter and finds that the solution given to him has a pH of 0.96. Find K_a for the acid HA.

41. (8 pts) (a) Draw the <u>structural</u> formula (showing all H atoms) for with a molecule that has a ring and that has the formula C_3H_6O.

Continued on the back.

(b) Draw the structural formula of a ketone that has the formula C_3H_6O (show all H atoms).

(c) Draw the structural formulas of two more molecules that each have the formula C_3H_6O but that are different from each other and from the molecules you drew in (a) and (b).

42. (5 pts) The reaction A + B → products is first order in A and is second order in B. In a 25°C solution with [A] = 0.40 M and [B] = 0.14 M, the rate of this reaction is 3.3×10^{-3} M/s. Find the rate constant for this reaction at 25°C.

43. (6 pts) Consider the nuclear reaction

$$^{238}_{92}\text{U} \rightarrow {}^{234}_{90}\text{Th} + {}^{4}_{2}\text{He}$$

The nuclei in this reaction have the masses

238.0003 amu for $^{238}_{92}\text{U}$, 233.9942 amu for $^{234}_{90}\text{Th}$ and 4.0015 amu for $^{4}_{2}\text{He}$.

(a) Find ΔE when one mole of $^{238}_{92}\text{U}$ nuclei undergoes this reaction

(b) Use the answer to (a) to find ΔE when one $^{238}_{92}\text{U}$ nucleus undergoes this reaction.

Extra credit

EC1 (1 pt) Are you taking the Chem 2 final today?

EC2 (1 pt)
EC3 (1 pt)