Version A

CHEM 1423 - Final Exam – May 12, 2015

Name________________________________

If you wish to have your final exam and course grade posted on the Web site, please provide me with a four (4) digit number which will be the ID number for your grade.

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Four (4) digit number for posting.

Problem (4 pts): A concentration cell is prepared with 0.60 M Calcium Nitrate, $Ca(NO_3)_2$, in the reference compartment (cathode) and a saturated solution of Calcium Phosphate, $Ca_3(PO_4)_2$, in the sample compartment (anode).

The cell reaction can be written as: $Ca(s)|Ca^{2+}(xx\ M)||Ca^{2+}(0.60\ M)|Ca(s)$

The measured cell voltage is +0.161 V. Calculate the Solubility Product, K_{sp}, of $Ca_3(PO_4)_2$

Conversions: 1 atm. = 760 torr

Constants: R = 0.082 L-atm/mol·K

R = 8.31 J/mol·K

R = 8.31×10^{-3} kJ/mol·K

$N_A = 6.02 \times 10^{23}$ mol^{-1}

F = 96,500 Coul/mol e^-

c = 3.00×10^8 m/s (speed of light)

Molar Masses: Given with each question: [M=xx]

PERIODIC TABLE OF THE ELEMENTS

Key: Atomic Number / Symbol / Atomic Mass (1 H 1.008)

	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIIIB	10	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1 H 1.008																	2 He 4.003
2	3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
3	11 Na 23.00	12 Mg 24.30											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	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
5	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 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
6	55 Cs 132.9	56 Ba 137.3	71 Lu 175.0	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra 226.0	103 Lr (260)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)									

Approved by the I.U.P.A.C. Council in Geneva, August 30, 1997

Lanthanide series													
57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.2	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0

Actinide series													
89 Ac 227.0	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np 237.0	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)

ELECTROCHEMISTRY INFORMATION

Table 1: Standard Reduction Potentials

Reduction Half-Reactions	**Eº (V)**
$F_2 + 2\ e^- \rightarrow 2\ F^-$	+2.87
$Au^{3+} + 3\ e^- \rightarrow Au$	+1.50
$Cl_2 + 2\ e^- \rightarrow 2\ Cl^-$	+1.36
$Br_2 + 2\ e^- \rightarrow 2\ Br^-$	+1.07
$Hg^{2+} + 2\ e^- \rightarrow Hg$	+0.86
$Ag^+ + 1\ e^- \rightarrow Ag$	+0.80
$I_2 + 2\ e^- \rightarrow 2\ I^-$	+0.54
$Cu^{2+} + 2\ e^- \rightarrow Cu$	+0.34
$Fe^{3+} + 3\ e^- \rightarrow Fe$	-0.04
$Sn^{2+} + 2\ e^- \rightarrow Sn$	-0.14
$Ni^{2+} + 2\ e^- \rightarrow Ni$	-0.25
$Zn^{2+} + 2\ e^- \rightarrow Zn$	-0.76
$Mn^{2+} + 2\ e^{--} \rightarrow Mn$	-1.18
$Al^{3+} + 3\ e^- \rightarrow Al$	-1.66
$Mg^{2+} + 2\ e^- \rightarrow Mg$	-2.37
$K^+ + 1\ e^- \rightarrow K$	-2.93
$Li^+ + 1\ e^- \rightarrow Li$	-3.05

Table 2: Some Reduction and Oxidation Potentials in Aqueous Solution

Reduction Potentials

$2\ H_2O + 2\ e^- \rightarrow H_2 + 2\ OH^-$	$E^o_{red} = -0.83$ V
$Al^{3+} + 3\ e^- \rightarrow Al$	$E^o_{red} = -1.66$ V
$Zn^{2+} + 2\ e^- \rightarrow Zn$	$E^o_{red} = -0.76$ V
$Mg^{2+} + 2\ e^- \rightarrow Mg$	$E^o_{red} = -2.37$ V
$Na^+ + 3\ e^- \rightarrow Na$	$E^o_{red} = -2.71$ V
$Fe^{2+} + 2\ e^- \rightarrow Fe$	$E^o_{red} = -0.44$ V

Oxidation Potentials

$2\ H_2O \rightarrow O_2 + 4\ H^+ + 4\ e^-$	$E^o_{oxid} = -1.23$ V
$2\ I^- \rightarrow I_2 + 2\ e^-$	$E^o_{oxid} = -0.54$ V
$2\ Br^- \rightarrow Br_2 + 2\ e^-$	$E^o_{oxid} = -1.07$ V
$2\ F^- \rightarrow F_2 + 2\ e^-$	$E^o_{oxid} = -2.87$ V

Some Electrochemical Equations

F = 96,500 C/mol e^- (Coulombs per mole of electrons)

1 J = 1 CxV [i.e. 1 Joule = 1 Coulomb x Volt]

$\Delta G^o = -nFE^o$

$$E = E^o - \frac{0.0592}{n} \cdot \log(Q)$$

Q = i x t i.e. Charge (in Coul) = Current (in Amps = Coul/sec) x time (in sec)]

E = Q x V i.e. Energy (in J) = Charge (in Coulombs) x Voltage (in Volts)
(note: 1 Coulomb-Volt = 1 Joule)

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(56) MULTIPLE CHOICE (Mark the one correct answer to each question on your scantron)

Turn in: (a) Your scantron with your name and answers (there is no need to bubble in your ID.

(b) The cover sheet with your Electrochemistry Problem + four (4) digit number if you would like your results posted on the course web site.

Each Multiple Choice question is worth 1 point. The problem is worth 4 points, yielding a total of 60 points on the test. Your score will be converted to a percentage prior to any further analysis.

1. Consider the hypothetical reaction, $3A + B \rightarrow 2C$. If the rate of change of [A] is $\Delta[A]/dt = -0.60$ M hr^{-1}. What is the "rate" of the reaction?

   (A) +0.20 M hr^{-1} (B) -0.40 M hr^{-1}

   (C) -0.20 M hr^{-r} (D) +0.40 M hr^{-1}

2. The rate of the chemical reaction involving two substances, A and B, is measured. It is found that if the initial concentration of A used is tripled, keeping the B concentration the same, the rate increases by a factor of nine (9) (relative to the first experiment). If the concentrations of both A and B are doubled, the rate increases by a factor of thirty-two (32) (relative to the first experiment). The rate law for this reaction is: Rate =

   (A) $k[A]^2[B]^2$ (B) $k[A][B]^3$ (C) $k[A]^2[B]^3$ (D) $k[A]^3[B]^2$

3. The reaction, A $\rightarrow$ Products, is of order "n" with respect to [A]; i.e. Rate = $k[A]^n$. When the initial concentration of A is 0.60 M, the initial rate is 0.50 Ms^{-1}. When the initial concentration of A is 0.20 M, the initial rate is 4.50 Ms^{-1}. The order of this reaction, n, is:

   (A) -2 (B) -1 (C) +1 (D) +2

4. The rate law for a given reaction, A $\rightarrow$ Products, is **fourth** order with respect to [A]? When the initial concentration of A is 0.80 M, the initial rate is 0.45 Ms^{-1}. The rate constant for this reaction is approximately:

   (A) 1.4 $M^{-3}s^{-1}$ (B) 0.73 $M^{-3}s^{-1}$ (C) 0.91 $M^{-3}s^{-1}$ (D) 1.1 $M^{-3}s^{-1}$

5. For the **first** order reaction, A $\rightarrow$ Products, the rate constant is 0.025 s^{-1}. If the initial concentration of A is 0.50 M, what is the approximate concentration of A after 20 s?

   (A) 0.40 M (B) 0.30 M (C) 0.26 M (D) 0.61 M

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6. For the **second** order reaction, A $\rightarrow$ Products, when the initial concentration of A is 0.90 M, it takes 40 s for the concentration to decrease to 0.30 M. The rate constant for this reaction is approximately:

   (A) 0.027 $M^{-1}s^{-1}$ (B) 0.056 $M^{-1}s^{-1}$ (C) 0.015 $M^{-1}s^{-1}$ (D) 0.082 $M^{-1}s^{-1}$

7. For the reaction, 2 NO(g) + O_2(g) $\rightarrow$ 2 NO_2(g), the reaction mechanism is:

   2 NO $\rightleftarrows$ N_2O_2 Fast Equilibrium (N_2O_2) is an intermediate

   N_2O_2 + O_2 $\rightarrow$ 2 NO_2 Slow rate determining step

   The overall rate equation for this reaction is:

   (A) Rate = k'$[NO]^2/[O_2]$ (B) Rate = k'$[O_2]$[2NO]

   (C) Rate = k'$[O_2]$[NO] (D) Rate = k'$[O_2][NO]^2$

For #8-#9: Consider the gas phase equilibrium, 2 $POBr_3$(g) $\rightarrow$ 2 PBr_3(g) + O_2(g).

8. For the above reaction, if the volume is **decreased**, the ratio $[PBr_3]/[POBr_3]$ will _______ and K_c will ______.

   (A) increase , increase (B) increase , remain constant

   (C) decrease , remain constant (D) decrease , decrease

9. For the above reaction, if Br_2(g) is added to the mixture at **constant pressure**, then the ratio $[PBr_3]/[POBr_3]$ will ________ and K_c will ____________

   (A) increase , increase (B) increase , remain constant

   (C) decrease , remain constant (D) remain constant , remain constant

10. Consider the gas phase equilibrium reaction, A(g) $\rightleftharpoons$ 2 B(g). If one initially fills a container with A at a concentration of 2.0 M, and then allows it to come to equilibrium, it is found that the equilibrium concentration of A is 1.6 M. Therefore, the value of the equilibrium constant, K_c is approximately:

    (A) 0.40 (B) 0.50 (C) 0.10 (D) 0.67

11. Consider the reaction: $2HBr(g) \underset{}{\overset{K_c}{\rightleftarrows}} H_2(g) + Br_2(g)$. The equilibrium constant is K_c = 15.0 at 100 ^oC. The Enthalpy Change for this reaction is ΔH^o = +70. kJ/mol. What is the approximate value of K_c at 50 ^oC?

    (A) 33. (B) 0.030 (C) 490 (D) 0.45

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12. The gas phase molecule, A, dissociates according to the equilibrium,

    A(g) ⇌ 3 B(g) + C(g). The equilibrium constant is $K_c = 1x10^{-3}$. If one puts an initial concentration of 2.0 M of A into a flask, what is the approximate concentration **of B** at equilibrium? [**NOTE**: You may assume that very little A dissociates]

    (A) 0.15 M (B) 0.28 M (C) 0.09 M (D) 0.15 M

13. The concentration of Copper (by mass) in a sample of water is 450 ppb. Approximately how many nanograms (ng) of Copper are contained in 150 mL of the solution?:

    (A) $6.8x10^4$ ng (B) $4.5x10^5$ ng (C) 68 ng

    (D) None of the above

14. When 16 grams of methanol, CH_3OH [M=32] is added to 108 grams of water [M=18], the density of the solution is 0.90 g/mL. The **Molarity** of methanol in this solution is:

    (A) 3.63 M (B) 4.17 M (C) 4.48 M (D) 4.63 M

15. A sample of ethylene glycol, $C_2H_6O_2$, is dissolved in 700 grams of water (K_f = 1.86 $^oC/m$). The freezing point of the solution is -3.6 ^oC. Approximately how many moles of ethylene glycol are dissolved in this sample?

    (A) 0.42 mol (B) 1.35 mol (C) 1.94 mol (D) 2.76 mol

16. Which of the following solutions has the **lowest** freezing point?

    (A) 0.32 m $C_6H_{12}O_{6a}$ (B) 0.10 m $Ca(NO_3)_2$

    (C) 0.09 m K_3PO_4 (D) 0.20 m NaBr

17. What is the approximate osmotic pressure, **in torr**, when $5.0x10^{-4}$ mol of the strong electrolyte, Calcium Phosphate [$Ca_3(PO_4)_2$] , is dissolved in 600 mL of aqueous solution at 25 ^oC?

    (A) 15 torr (B) 77 torr (C) 0.10 torr (D) 46 torr

18. The normal boiling point of pure CCl_4(l) is 77.0 ^oC and the boiling point elevation constant is 5.0 $^oC/m$. When 60. grams of an unknown compound is placed in 750 grams of CCl_4, the boiling point of the solution is 80.5 ^oC. The Molar Mass of the unknown compound is approximately:

    (A) 64 g/mol (B) 86 g/mol (C) 114 g/mol (D) 153 g/mol

19. Approximately how many grams of NaOH [M=40] must be dissolved in 15. L of aqueous solution to prepare a solution with pH = 9.7?

    (A) $7.5x10^{-2}$ g (B) $7.5x10^{-4}$ g (C) $2.0x10^{-3}$ g (D) $3.0x10^{-2}$ g

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20. The pH of a 0.10 M acetate (KAc) is 8.90 . The base equilibrium constnat, K_b , of the acetate ion (Ac^-) is approximately:

    (A) $1.6x10^{-5}$ (B) $6.3x10^{-10}$ (C) $1.6x10^{-17}$ (D) $4.8x10^{-7}$

21. Benzoic Acid (HBenz) has an acid dissociation constant of $1.6x10^{-9}$. What is the approximate pH a 0.20 M solution of aqueous sodium benzoate (NaBenz)?

    (A) 11.0 (B) 9.3 (C) 4.7 (D) 3.0

22. The weak base, aniline (Anil), has a base equilibrium constant, $K_b = 4.3x10^{-10}$. What is the pH of a 0.05 M aqueous solution of anilinium chloride (AnilHCl)?

    (A) 11.0 (B) 8.7 (C) 5.3 (D) 3.0

23. If added to 2 L of 0.80 M NaOH, which one of the following would form a buffer?

    (A) 2. L of 0.50 M Nitric Acid (HNO_3)

    (B) 2. L of 0.50 M Acetic Acid (HAc)

    (C) 2. L of 1.0 M Lactic Acid (HLac)

    (D) 2. L of 1.0 M Potassium Acetate (KAc)

For #24 - #28: Tellurous acid, H_2TeO_3, is a diprotic acid with acid dissociation constants, $K_a' = 3.0x10^{-3}$ and $K_a'' = 2.0x10^{-8}$

24. What is the pH of a 0.04 M solution of sodium tellurite, Na_2TeO_3 ?

    (A) 9.45 (B) 10.15 (C) 11.25 (D) 3.85

25. What is the pH of a solution containing 0.20 M $KHTeO_3$ and 0.50 M Na_2TeO_3?

    (A) 2.92 (B) 7.30 (C) 8.10 (D) 2.12

26. What is the pH of a solution prepared by adding 0.35 mol of KOH to 2.0 L of 0.50 M H_2TeO_3?

    (A) 7.43 (B) 2.79 (C) 2.06 (D) 2.25

27. What is the pH of a solution prepared by adding 2 L of 0.70 M HCl to 2 L of 0.45 M Na_2TeO_3 ?

    (A) 7.60 (B) 2.42 (C) 7.80 (D) 2.62

28. What ratio of $[HTeO_3^-]/[TeO_3^{2-}]$ will give a pH of 7.00

    (A) 5.0 (B) 0.38 (C) 2.63 (D) 0.20

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29. 600 mL of 0.30 M KOH(aq) are required to completely neutralize 400 mL of an aqueous H_2SO_4(aq) solution. What is the Molarity of the acid solution?

(A) 0.23 M (B) 0.36 M (C) 0.45 M (D) 0.90 M

30. Consider the slightly soluble compound, silver carbonate, Ag_2CO_3. The solubility product constant is $K_{sp} = 6.2\times10^{-12}$.

What is the concentration of silver ions, $[Ag^+]$, in a solution containing Ag_2CO_3 and 0.1 M K_2CO_3(aq)?

(A) 1.6×10^{-5} M (B) 7.9×10^{-6} M (C) 3.9×10^{-6} M (D) 2.5×10^{-6} M

31. Consider the reaction: $2\ NO_2(g) \rightarrow N_2(g) + 2\ O_2(g)$, $\Delta H^o < 0$. This reaction is:

(A) Reactant Favored at all temperatures

(B) Product Favored at all temperatures

(C) Product Favored at low temperature

(D) Product Favored at high temperature

32. For a hypothetical reaction, $A \rightleftharpoons B$, $\Delta H^o = +80$ kJ. The equilibrium constant for the reaction is 3.0×10^{-11} at 25 ^oC. ΔS^o for this reaction is approximately:

(A) -470 J/K (B) -67 J/K (C) +470 J/K (D) +67 J/K

33. The enthalpy of vaporization of liquid benzene, C_6H_6(l), is +30.7 kJ/mol. What is the entropy change of the **surroundings**, ΔS_{surr}, for the condensation of 0.50 mol of benzene gas at the boiling point, 80 ^oC?

(A) -87. J/K (B) -192 J/K (C) -43.5 J/K (D) +87 J/K

34. For the reaction, $2\ N_2O_5(g) \rightleftharpoons 2\ N_2(g) + 5\ O_2(g)$, is $\Delta G^o = -236$ kJ at 25^{o}C. What is the approximate value of the Equilibrium Constant for the **related reaction:** $N_2(g) + (5/2)\ O_2(g) \rightleftharpoons N_2O_5(g)$ at 25 ^oC?

(A) 2.0×10^{-21} (B) $2.4\times10^{+41}$ (C) 2.0×10^{-42}

(D) None of the above

35. For the reaction, $2\ K_2O(s) \rightarrow 4\ K(s) + O_2$(g, $\Delta H^o = +48$ kJ and $\Delta S^o = +85$ J/K. This reaction is _________ favored at temperatures **below** _______ ^oC (Celsius).

(A) Product , 292 ^oC (B) Product , 565 ^oC

(C) Reactant , 292 ^oC (D) Reactant , 565 ^oC

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36. For the reaction, $N_2(g) + 3\ H_2(g) \rightleftharpoons 2\ NH_3(g)$, the equilibrium constant, K = 220, at 240 °C. What is the approximate value of ΔG at 240 °C when $P(N_2) = P(H_2) = 0.10$ bar and $P(NH_3) = 0.50$ bar?

    (A) -33.4 kJ (B) -7.4 kJ (C) +10.4 kJ (D) -56.4 kJ

37. The reaction, $A \rightarrow B$, is **exergonic** at 25 °C and the Entropy change is -95 J/K. What can be concluded about the Enthalpy change for this reaction?

    (A) $\Delta H < 45.6$ kJ (B) $\Delta H < -28.3$ J/K (C) $\Delta H > +28.3$ kJ

    (D) ΔH cannot be determined without knowing the sign of ΔG

38. Regarding the following reaction, which of the statements below is/are correct?

    $$Fe_2O_3(s) + 3\ CO(g) \rightarrow 2\ Fe + 3\ CO_2(g)$$

    (1) Fe_2O_3 is the oxidizing agent (2) Fe is reduced
    (3) 6 electrons are transfered (4) CO is oxidized

    (A) 1 & 4 (B) 1 & 3 & 4 (C) 3 & 4 (D) 2 & 3

39. For the electrochemical cell given by $Cu|Cu^{2+}||Au^{3+}|Au$, which of the following statements is/are correct?

    (1) The cathode reaction is $Au^{3+} + 3\ e^- \rightarrow Au$
    (2) Electrons flow from the Au electrode to the Cu electrode through an external circuit
    (3) The anode reaction is $Cu \rightarrow Cu^{2+} + 2\ e^-$
    (4) If the half-cells are separated by a KNO_3 salt bridge, NO_3^- ions flow towards the Au electrode

    (A) 1 & 2 & 3 (B) 1 & 2 & 4 (C) 1 & 3 (D) 2 & 3 & 4

For #40 - #46: Use Table 1 (Standard Reduction Potentials), as necessary, near the top of the test.

40. Which of the following reactions are **reactant** favored?

    (1) $Hg^{2+} + 2\ Cl^- \rightarrow Hg + Cl_2$ (2) $2\ Ag^+ + 2\ I^- \rightarrow 2\ Ag + 2\ I_2$

    (3) $Hg^{2+} + 2\ Fe^{2+} \rightarrow Hg + 2\ Fe^{3+}$ (4) $Cu^{2+} + 2\ Ag \rightarrow 2\ Ag^+ + Cu$

    (A) 2 & 3 (B) 1 & 3 & 4 (C) 3 only (D) 1 & 4

41. For the redox reaction, $2\ K^+ + Cd \rightarrow 2\ K + Cd^{2+}$, the cell potential is: $E^o_{Cell} = -2.53$ V. What is the reduction potential for Cd^{2+} ?

    (A) -0.40 V (B) -5.46 V (C) -3.33 V (D) +0.40 V

42. What is the standard Gibbs Free Energy change for the electrochemical reaction, $Ni^{2+} + 2\ I^- \rightarrow Ni + I_2$?

    (A) -56 kJ (B) +76 kJ (C) +56 kJ (D) +152 kJ

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43. For the redox reaction, 2 Al^{3+} + 3 Mn $\rightarrow$ 2 Al + 3 Mn^{2+}, the cell potential is: E^o_{cell} = -0.48 V. What is the equilibrium constant, K, for this reaction?

(A) $4.7x10^{-25}$ (B) $2.2x10^{-49}$ (C) $4.5x10^{+48}$ (D) $7.8x10^{-9}$

44. Consider the following electrochemical cell reaction (values in parentheses indicate Molar Concentrations): Ag(s)|Ag^{+}(0.002 M)||Au^{3+}(3.00 M)|Au(s) . For this reaction, E^o_{cell} = +0.70 V. What is the cell potential, E_{cell}, at the concentrations shown in the reaction?

(A) +0.36 V (B) +1.21 V (C) +0.53 V (D) +0.87 V

45. The concentration of lead [Pb, M=207.2] in drinking water was determined using a concentration cell with 0.30 M lead(II) nitrate, $Pb(NO_3)_2$, in the reference cell (the cathode) and a sample of water with an unknown concentration of Pb^{2+}(xx) in the sample cell (the anode).
In cell notation, this can be written as: Pb(s)|Pb^{2+}(xx)||Pb^{2+}(0.20 M)|Pb(s).

The cell potential in the above concentration cell was measured to be +0.140 V. Therefore, the concentration of lead in the sample, in **milligrams per Liter (mg/L)** is approximately:

(A) 1.2 mg/L (B) 550 mg/L (C) 3.9 mg/L (D) $3.9x10^{-3}$ mg/L

46. The reaction for the reduction of O_2 in the environment and the reduction potetial for this reaction is given by: $O_2 + 2\ H_2O + 4\ e^- \rightarrow 4\ OH^-$ $E_{red}^o(O_2)$ = +0.40 V

Based upon electrochemical considerations, which of the following metals would be expected to corrode (i.e. undergo oxidation) in the presence of O_2 and H_2O? Ag, Sn, Cu, Hg

(A) Cu only (B) Hg & Cu (C) Sn & Cu (D) Ag & Hg

For #47 - #48: Use Table 2 (Some Reduction and Oxidation Potentials in Aqueous Solution) near the top of the test.

47. If aqueous Zn(II) Fluoride, ZnF_2(aq) is placed in an electrolysis cell, and a voltage is applied, what will be the principal products of the electrolysis?

(A) Zn , F_2 (B) Zn , O_2 , H^+
(C) F_2 , H_2 , OH^- (C) H_2 , OH^- , O_2 , H^+

48. If aqueous Aluminum Iodide, AlI_3(aq) is placed in an electrolysis cell, and a voltage is applied, what will be the principal products of the electrolysis?

(A) Al , I_2 (B) Al , O_2 , H^+
(C) I_2 , H_2 , OH^- (C) H_2 , OH^- , O_2 , H^+

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49. Approximately how long would it take to electroplate a metal surface with 0.15 g of Nickel [M=58.7] metal from a $Ni(NO_3)_2(aq)$ solution with a current of 150 mA (milliAmps)?

(A) 54.8 min (B) 157 min (C) 27.5 min (D) 32.9 min

50. A total of 850 kJ of energy was required to plate out Al(s) [M=27.] by electrolysis of a $Al(NO_3)_3(aq)$ solution. The voltage was 8. Volts. Approximately how many grams of Al(s) were plated out by electrolysis?

(A) 89.2 g (B) 9.9 g (C) 5.4 g (D) 29.7 g

51. Consider the nuclear reaction, ${}^{252}_{98}Cf + X \rightarrow 3\,{}^{1}_{0}n + {}^{259}_{103}Lr$. What is X in this equation?

(A) ${}^{4}_{2}He$ (B) ${}^{8}_{5}B$ (C) ${}^{16}_{8}O$ (D) ${}^{10}_{5}B$

52. What nuclide will undergo electron capture to form Pt-195 ?

(A) Ir-196 (B) Ir-195 (C) Au-195 (D) Pt-196

53. Which of the following decay paths is the most likely one for Rn-222 ?

(A) ${}^{222}_{86}Ra \rightarrow {}^{0}_{+1}e + {}^{222}_{85}At$ (B) ${}^{222}_{86}Ra \rightarrow {}^{4}_{2}He + {}^{218}_{84}Po$

(C) ${}^{222}_{86}Ra \rightarrow {}^{0}_{-1}e + {}^{222}_{87}Fr$ (D) ${}^{222}_{86}Ra + {}^{0}_{-1}e \rightarrow {}^{222}_{85}At$

54. Which of the following is/are likely decay paths for Mg-22. Stable isotopes in this range typically have N/Z = 1.05.

(1) ${}^{22}_{12}Mg \rightarrow {}^{0}_{-1}e + {}^{22}_{13}Al$ (2) ${}^{22}_{12}Mg \rightarrow {}^{0}_{+1}e + {}^{22}_{11}Na$

(3) ${}^{22}_{12}Mg + {}^{0}_{-1}e \rightarrow {}^{22}_{11}Na$ (4) ${}^{22}_{12}Mg \rightarrow {}^{4}_{2}He + {}^{18}_{10}Ne$

(A) 2 & 3 (B) 4 only (C) 1 & 4 (D) 1 & 2

Two more MC questions on next page.

Version A

55. One nuclear fusion reaction involves the reaction of a deuterium and tritium nucleus to form helium: ${}^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n$. This reaction is highly exothermic because:

(A) The n-n repulsions in deuterium and tritium are higher than in helium

(B) Helium has a lower Binding Energy per nucleon than deuterium or tritium

(C) The p-p attractions are greater in helium than in deuterium or tritoi,

(D) Helium has a higher Binding Energy per nucleon than deuterium or tritium

56. Use the Molar Masses below to calculate the approximate Binding Energy per Nucleon (Eb/N) of Pb-208.

m(${}_{1}{}^{1}H$) = 1.008 g/mol , m(${}_{0}{}^{1}n$) = 1.009 g/mol , m(${}_{82}{}^{208}Pb$) = 207.977 g/mol

(A) $1.6\text{x}10^{11}$ kJ/mol

(B) $7.8\text{x}10^{11}$ kJ/mol

(C) $7.8\text{x}10^{8}$ kJ/mol

(D) $1.6\text{x}10^{14}$ kJ/mol

Version B

CHEM 1423 - Final Exam – May 12, 2015

Name________________________________

If you wish to have your final exam and course grade posted on the Web site, please provide me with a four (4) digit number which will be the ID number for your grade.

____

Four (4) digit number for posting.

Problem (4 pts): A concentration cell is prepared with 0.20 M Calcium Nitrate, $Ca(NO_3)_2$, in the reference compartment (cathode) and a saturated solution of Calcium Phosphate, $Ca_3(PO_4)_2$, in the sample compartment (anode).

The cell reaction can be written as: $Ca(s)|Ca^{2+}(xx\ M)||Ca^{2+}(0.20\ M)|Ca(s)$

The measured cell voltage is +0.146 V. Calculate the Solubility Product, K_{sp}, of $Ca_3(PO_4)_2$

Conversions: 1 atm. = 760 torr

Constants: R = 0.082 L-atm/mol·K

R = 8.31 J/mol·K

R = 8.31×10^{-3} kJ/mol·K

$N_A = 6.02 \times 10^{23}\ mol^{-1}$

F = 96,500 Coul/mol e^-

c = 3.00×10^{8} m/s (speed of light)

Molar Masses: Given with each question: [M=xx]

PERIODIC TABLE OF THE ELEMENTS

Key: 1 H 1.008 — Atomic Number, Symbol, Atomic Mass

	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIIIB	10	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1 H 1.008																	2 He 4.003
2	3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
3	11 Na 23.00	12 Mg 24.30											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	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
5	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 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
6	55 Cs 132.9	56 Ba 137.3	71 Lu 175.0	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra 226.0	103 Lr (260)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)									

Lanthanide series

57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.2	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0

Actinide series

89 Ac 227.0	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np 237.0	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)

Approved by the I.U.P.A.C. Council in Geneva, August 30, 1997

ELECTROCHEMISTRY INFORMATION

Table 1: Standard Reduction Potentials

Reduction Half-Reactions	E^o (V)
$F_2 + 2\ e^- \rightarrow 2\ F^-$	+2.87
$Au^{3+} + 3\ e^- \rightarrow Au$	+1.50
$Cl_2 + 2\ e^- \rightarrow 2\ Cl^-$	+1.36
$Br_2 + 2\ e^- \rightarrow 2\ Br^-$	+1.07
$Hg^{2+} + 2\ e^- \rightarrow Hg$	+0.86
$Ag^+ + 1\ e^- \rightarrow Ag$	+0.80
$I_2 + 2\ e^- \rightarrow 2\ I^-$	+0.54
$Cu^{2+} + 2\ e^- \rightarrow Cu$	+0.34
$Fe^{3+} + 3\ e^- \rightarrow Fe$	-0.04
$Sn^{2+} + 2\ e^- \rightarrow Sn$	-0.14
$Ni^{2+} + 2\ e^- \rightarrow Ni$	-0.25
$Zn^{2+} + 2\ e^- \rightarrow Zn$	-0.76
$Mn^{2+} + 2\ e^{--} \rightarrow Mn$	-1.18
$Al^{3+} + 3\ e^- \rightarrow Al$	-1.66
$Mg^{2+} + 2\ e^- \rightarrow Mg$	-2.37
$K^+ + 1\ e^- \rightarrow K$	-2.93
$Li^+ + 1\ e^- \rightarrow Li$	-3.05

Table 2: Some Reduction and Oxidation Potentials in Aqueous Solution

Reduction Potentials

$2\ H_2O + 2\ e^- \rightarrow H_2 + 2\ OH^-$	$E^o_{red} = -0.83$ V
$Al^{3+} + 3\ e^- \rightarrow Al$	$E^o_{red} = -1.66$ V
$Zn^{2+} + 2\ e^- \rightarrow Zn$	$E^o_{red} = -0.76$ V
$Mg^{2+} + 2\ e^- \rightarrow Mg$	$E^o_{red} = -2.37$ V
$Na^+ + 3\ e^- \rightarrow Na$	$E^o_{red} = -2.71$ V
$Fe^{2+} + 2\ e^- \rightarrow Fe$	$E^o_{red} = -0.44$ V

Oxidation Potentials

$2\ H_2O \rightarrow O_2 + 4\ H^+ + 4\ e^-$	$E^o_{oxid} = -1.23$ V
$2\ I^- \rightarrow I_2 + 2\ e^-$	$E^o_{oxid} = -0.54$ V
$2\ Br^- \rightarrow Br_2 + 2\ e^-$	$E^o_{oxid} = -1.07$ V
$2\ F^- \rightarrow F_2 + 2\ e^-$	$E^o_{oxid} = -2.87$ V

Some Electrochemical Equations

F = 96,500 C/mol e^- (Coulombs per mole of electrons)

1 J = 1 CxV [i.e. 1 Joule = 1 Coulomb x Volt]

$\Delta G^o = -nFE^o$

$$E = E^o - \frac{0.0592}{n} \cdot \log(Q)$$

Q = i x t i.e. Charge (in Coul) = Current (in Amps = Coul/sec) x time (in sec)]

E = Q x V i.e. Energy (in J) = Charge (in Coulombs) x Voltage (in Volts)
(note: 1 Coulomb-Volt = 1 Joule)

Version B

(56) MULTIPLE CHOICE (Mark the one correct answer to each question on your scantron)

Turn in: (a) Your scantron with your name and answers (there is no need to bubble in your ID.

(b) The cover sheet with your Electrochemistry Problem + four (4) digit number if you would like your results posted on the course web site.

Each Multiple Choice question is worth 1 point. The problem is worth 4 points, yielding a total of 60 points on the test. Your score will be converted to a percentage prior to any further analysis.

1. The reaction, A $\rightarrow$ Products, is of order "n" with respect to [A]; i.e. Rate = $k[A]^n$. When the initial concentration of A is 0.60 M, the initial rate is 0.50 Ms^{-1}. When the initial concentration of A is 0.20 M, the initial rate is 4.50 Ms^{-1}. The order of this reaction, n, is:

   (A) +2 (B) -1 (C) +1 (D) -2

2. The rate law for a given reaction, A $\rightarrow$ Products, is **fourth** order with respect to [A]? When the initial concentration of A is 0.80 M, the initial rate is 0.45 Ms^{-1}. The rate constant for this reaction is approximately:

   (A) 1.4 $M^{-3}s^{-1}$ (B) 1.1 $M^{-3}s^{-1}$ (C) 0.91 $M^{-3}s^{-1}$ (D) 0.73 $M^{-3}s^{-1}$

3. For the **first** order reaction, A $\rightarrow$ Products, the rate constant is 0.025 s^{-1}. If the initial concentration of A is 0.50 M, what is the approximate concentration of A after 20 s?

   (A) 0.40 M (B) 0.26 M (C) 0.30 M (D) 0.61 M

4. The rate of the chemical reaction involving two substances, A and B, is measured. It is found that if the initial concentration of A used is tripled, keeping the B concentration the same, the rate increases by a factor of nine (9) (relative to the first experiment). If the concentrations of both A and B are doubled, the rate increases by a factor of thirty-two (32) (relative to the first experiment). The rate law for this reaction is: Rate =

   (A) $k[A]^2[B]^2$ (B) $k[A][B]^3$ (C) $k[A]^3[B]^2$ (D) $k[A]^2[B]^3$

5. Consider the hypothetical reaction, 3A + B $\rightarrow$ 2C. If the rate of change of [A] is $\Delta[A]/dt$ = -0.60 M hr^{-1}. What is the "rate" of the reaction?

   (A) -0.40 M hr^{-1} (B) +0.40 M hr^{-1}

   (C) -0.20 M hr^{-r} (D) +0.20 M hr^{-1}

Version B

6. For the reaction, $2\ NO(g) + O_2(g) \rightarrow 2\ NO_2(g)$, the reaction mechanism is:

$2\ NO \rightleftarrows N_2O_2$	Fast Equilibrium (N_2O_2) is an intermediate
$N_2O_2 + O_2 \rightarrow 2\ NO_2$	Slow rate determining step

The overall rate equation for this reaction is:

(A) Rate = k'$[NO]^2/[O_2]$ (B) Rate = k'$[O_2][2NO]$

(C) Rate = k'$[O_2][NO]^2$ (D) Rate = k'$[O_2][NO]$

7. For the **second** order reaction, A → Products, when the initial concentration of A is 0.90 M, it takes 40 s for the concentration to decrease to 0.30 M. The rate constant for this reaction is approximately:

(A) 0.056 $M^{-1}s^{-1}$ (B) 0.027 $M^{-1}s^{-1}$ (C) 0.015 $M^{-1}s^{-1}$ (D) 0.082 $M^{-1}s^{-1}$

For #8-#9: Consider the gas phase equilibrium, $2\ POBr_3(g) \rightarrow 2\ PBr_3(g) + O_2(g)$.

8. For the above reaction, if $Br_2(g)$ is added to the mixture at **constant pressure**, then the ratio $[PBr_3]/[POBr_3]$ will _______ and K_c will ___________

(A) increase , increase (B) decrease , remain constant

(C) increase , remain constant (D) remain constant , remain constant

9. For the above reaction, if the volume is **decreased**, the ratio $[PBr_3]/[POBr_3]$ will ______ and K_c will _____.

(A) increase , increase (B) decrease , remain constant

(C) increase , remain constant (D) decrease , decrease

10. Consider the reaction: $2HBr(g) \xrightleftharpoons{K_c} H_2(g) + Br_2(g)$. The equilibrium constant is K_c = 15.0 at 100 °C. The Enthalpy Change for this reaction is ΔH^o = +70. kJ/mol. What is the approximate value of K_c at 50 °C?

(A) 33. (B) 0.45 (C) 490 (D) 0.030

11. Consider the gas phase equilibrium reaction, $A(g) \rightleftharpoons 2\ B(g)$. If one initially fills a container with A at a concentration of 2.0 M, and then allows it to come to equilibrium, it is found that the equilibrium concentration of A is 1.6 M. Therefore, the value of the equilibrium constant, K_c is approximately:

(A) 0.10 (B) 0.50 (C) 0.67 (D) 0.40

Version B

12. The gas phase molecule, A, dissociates according to the equilibrium,

    $A(g) \rightleftharpoons 3\,B(g) + C(g)$. The equilibrium constant is $K_c = 1x10^{-3}$. If one puts an initial concentration of 2.0 M of A into a flask, what is the approximate concentration **of B** at equilibrium? [**NOTE**: You may assume that very little A dissociates]

    (A) 0.15 M (B) 0.15 M (C) 0.09 M (D) 0.28 M

13. When 16 grams of methanol, CH_3OH [M=32] is added to 108 grams of water [M=18], the density of the solution is 0.90 g/mL. The **Molarity** of methanol in this solution is:

    (A) 4.48 M (B) 4.17 M (C) 3.63 M (D) 4.63 M

14. The concentration of Copper (by mass) in a sample of water is 450 ppb. Approximately how many nanograms (ng) of Copper are contained in 150 mL of the solution?:

    (A) 68 ng (B) $4.5x10^5$ ng (C) $6.8x10^4$ ng

    (D) None of the above

15. Which of the following solutions has the **lowest** freezing point?

    (A) 0.32 m $C_6H_{12}O_{6a}$ (B) 0.20 m NaBr

    (C) 0.10 m $Ca(NO_3)_2$ (D) 0.09 m K_3PO_4

16. A sample of ethylene glycol, $C_2H_6O_2$, is dissolved in 700 grams of water (K_f = 1.86 $^oC/m$). The freezing point of the solution is -3.6 ^oC. Approximately how many moles of ethylene glycol are dissolved in this sample?

    (A) 1.35 mol (B) 0.42 mol (C) 1.94 mol (D) 2.76 mol

17. The normal boiling point of pure $CCl_4(l)$ is 77.0 ^oC and the boiling point elevation constant is 5.0 $^oC/m$. When 60. grams of an unknown compound is placed in 750 grams of CCl_4, the boiling point of the solution is 80.5 ^oC. The Molar Mass of the unknown compound is approximately:

    (A) 64 g/mol (B) 86 g/mol (C) 153 g/mol (D) 114 g/mol

18. What is the approximate osmotic pressure, **in torr**, when $5.0x10^{-4}$ mol of the strong electrolyte, Calcium Phosphate [$Ca_3(PO_4)_2$] , is dissolved in 600 mL of aqueous solution at 25 ^oC?

    (A) 77 torr (B) 15 torr (C) 0.10 torr (D) 46 torr

19. Approximately how many grams of NaOH [M=40] must be dissolved in 15. L of aqueous solution to prepare a solution with pH = 9.7?

    (A) $7.5x10^{-2}$ g (B) $3.0x10^{-2}$ g (C) $2.0x10^{-3}$ g (D) $7.5x10^{-4}$ g

Version B

20. The weak base, aniline (Anil), has a base equilibrium constant, $K_b = 4.3x10^{-10}$. What is the pH of a 0.05 M aqueous solution of anilinium chloride (AnilHCl)?

(A) 11.0 (B) 3.0 (C) 5.3 (D) 8.7

21. Benzoic Acid (HBenz) has an acid dissociation constant of $1.6x10^{-9}$. What is the approximate pH a 0.20 M solution of aqueous sodium benzoate (NaBenz)?

(A) 9.3 (B) 3.0 (C) 11.0 (D) 4.7

22. The pH of a 0.10 M acetate (KAc) is 8.90 . The base equilibrium constnat, K_b , of the acetate ion (Ac^-) is approximately:

(A) $1.6x10^{-5}$ (B) $6.3x10^{-10}$ (C) $1.6x10^{-17}$ (D) $4.8x10^{-7}$

23. If added to 2 L of 0.80 M NaOH, which one of the following would form a buffer?

(A) 2. L of 0.50 M Nitric Acid (HNO_3)

(B) 2. L of 1.0 M Lactic Acid (HLac)

(C) 2. L of 0.50 M Acetic Acid (HAc)

(D) 2. L of 1.0 M Potassium Acetate (KAc)

For #24 - #28: Tellurous acid, H_2TeO_3, is a diprotic acid with acid dissociation constants, $K_a' = 3.0x10^{-3}$ and $K_a'' = 2.0x10^{-8}$

24. What is the pH of a solution containing 0.20 M $KHTeO_3$ and 0.50 M Na_2TeO_3?

(A) 8.10 (B) 7.30 (C) 2.92 (D) 2.12

25. What is the pH of a solution prepared by adding 0.35 mol of KOH to 2.0 L of 0.50 M H_2TeO_3?

(A) 7.43 (B) 2.79 (C) 2.25 (D) 2.06

26. What is the pH of a solution prepared by adding 2 L of 0.70 M HCl to 2 L of 0.45 M Na_2TeO_3 ?

(A) 7.60 (B) 2.62 (C) 7.80 (D) 2.42

27. What is the pH of a 0.04 M solution of sodium tellurite, Na_2TeO_3 ?

(A) 10.15 (B) 9.45 (C) 11.25 (D) 3.85

28. What ratio of $[HTeO_3^-]/[TeO_3^{2-}]$ will give a pH of 7.00

(A) 2.63 (B) 0.38 (C) 5.0 (D) 0.20

Version B

29. Consider the slightly soluble compound, silver carbonate, Ag_2CO_3. The solubility product constant is $K_{sp} = 6.2 \times 10^{-12}$.

What is the concentration of silver ions, $[Ag^+]$, in a solution containing Ag_2CO_3 and 0.1 M $K_2CO_3(aq)$?

(A) 1.6×10^{-5} M (B) 2.5×10^{-6} M (C) 3.9×10^{-6} M (D) 7.9×10^{-6} M

30. 600 mL of 0.30 M KOH(aq) are required to completely neutralize 400 mL of an aqueous $H_2SO_4(aq)$ solution. What is the Molarity of the acid solution?

(A) 0.45 M (B) 0.36 M (C) 0.23 M (D) 0.90 M

31. For a hypothetical reaction, $A \rightleftharpoons B$, $\Delta H^o = +80$ kJ. The equilibrium constant for the reaction is 3.0×10^{-11} at 25 ^{o}C. ΔS^o for this reaction is approximately:

(A) -470 J/K (B) +67 J/K (C) +470 J/K (D) -67 J/K

32. Consider the reaction: $2\ NO_2(g) \rightarrow N_2(g) + 2\ O_2(g)$, $\Delta H^o < 0$. This reaction is:

(A) Product Favored at all temperatures

(B) Reactant Favored at all temperatures

(C) Product Favored at low temperature

(D) Product Favored at high temperature

33. For the reaction, $2\ N_2O_5(g) \rightleftharpoons 2\ N_2(g) + 5\ O_2(g)$, is $\Delta G^o = -236$ kJ at 25^{o}C. What is the approximate value of the Equilibrium Constant for the **related reaction:** $N_2(g) + (5/2)\ O_2(g) \rightleftharpoons N_2O_5(g)$ at 25 ^{o}C?

(A) 2.0×10^{-21} (B) $2.4 \times 10^{+41}$ (C) 2.0×10^{-42}

(D) None of the above

34. For the reaction, $2\ K_2O(s) \rightarrow 4\ K(s) + O_2(g$, $\Delta H^o = +48$ kJ and $\Delta S^o = +85$ J/K. This reaction is _________ favored at temperatures **below** _______ ^{o}C (Celsius).

(A) Reactant , 292 ^{o}C (B) Reactant , 565 ^{o}C

(C) Product , 292 ^{o}C (D) Product , 565 ^{o}C

35. The enthalpy of vaporization of liquid benzene, $C_6H_6(l)$, is +30.7 kJ/mol. What is the entropy change of the **surroundings**, ΔS_{surr}, for the condensation of 0.50 mol of benzene gas at the boiling point, 80 ^{o}C?

(A) -87. J/K (B) -192 J/K (C) +87 J/K (D) -43.5 J/K

Version B

36. The reaction, A $\rightarrow$ B, is **exergonic** at 25 ^oC and the Entropy change is -95 J/K. What can be concluded about the Enthalpy change for this reaction?

(A) $\Delta H < 45.6$ kJ (B) $\Delta H > +28.3$ J/K (C) $\Delta H < -28.3$ kJ

(D) ΔH cannot be determined without knowing the sign of ΔG

37. For the reaction, $N_2(g) + 3\ H_2(g) \rightleftharpoons 2\ NH_3(g)$, the equilibrium constant, K = 220, at 240 ^oC. What is the approximate value of ΔG at 240 ^oC when $P(N_2) = P(H_2) =$ 0.10 bar and $P(NH_3) = 0.50$ bar?

(A) +10.4 kJ (B) -7.4 kJ (C) -33.4 kJ (D) -56.4 kJ

38. For the electrochemical cell given by $Cu|Cu^{2+}||Au^{3+}|Au$, which of the following statements is/are correct?

(1) The cathode reaction is $Au^{3+} + 3\ e^- \rightarrow Au$
(2) Electrons flow from the Au electrode to the Cu electrode through an external circuit
(3) The anode reaction is $Cu \rightarrow Cu^{2+} + 2\ e^-$
(4) If the half-cells are separated by a KNO_3 salt bridge, NO_3^- ions flow towards the Au electrode

(A) 1 & 3 (B) 1 & 2 & 4 (C) 1 & 2 & 3 (D) 2 & 3 & 4

39. Regarding the following reaction, which of the statements below is/are correct?

$$Fe_2O_3(s) + 3\ CO(g) \rightarrow 2\ Fe + 3\ CO_2(g)$$

(1) Fe_2O_3 is the oxidizing agent (2) Fe is reduced
(3) 6 electrons are transfered (4) CO is oxidized

(A) 3 & 4 (B) 1 & 4 (C) 1 & 3 & 4 (D) 2 & 3

For #40 - #46: Use Table 1 (Standard Reduction Potentials), as necessary, near the top of the test.

40. For the redox reaction, $2\ K^+ + Cd \rightarrow 2\ K + Cd^{2+}$, the cell potential is: $E^o_{Cell} = -2.53$ V. What is the reduction potential for Cd^{2+} ?

(A) +0.40 V (B) -5.46 V (C) -3.33 V (D) -0.40 V

41. Which of the following reactions are **reactant** favored?

(1) $Hg^{2+} + 2\ Cl^- \rightarrow Hg + Cl_2$ (2) $2\ Ag^+ + 2\ I^- \rightarrow 2\ Ag + 2\ I_2$
(3) $Hg^{2+} + 2\ Fe^{2+} \rightarrow Hg + 2\ Fe^{3+}$ (4) $Cu^{2+} + 2\ Ag \rightarrow 2\ Ag^+ + Cu$

(A) 2 & 3 (B) 1 & 4 (C) 3 only (D) 1 & 3 & 4

42. What is the standard Gibbs Free Energy change for the electrochemical reaction, $Ni^{2+} + 2\ I^- \rightarrow Ni + I_2$?

(A) -56 kJ (B) +76 kJ (C) +56 kJ (D) +152 kJ

Version B

43. Consider the following electrochemical cell reaction (values in parentheses indicate Molar Concentrations): $Ag(s)|Ag^{+}(0.002\ M)||Au^{3+}(3.00\ M)|Au(s)$. For this reaction, E^{o}_{cell} = +0.70 V. What is the cell potential, E_{cell}, at the concentrations shown in the reaction?

(A) +0.36 V (B) +0.87 V (C) +0.53 V (D) +1.21 V

44. For the redox reaction, $2\ Al^{3+} + 3\ Mn \rightarrow 2\ Al + 3\ Mn^{2+}$, the cell potential is: E^{o}_{cell} = -0.48 V. What is the equilibrium constant, K, for this reaction?

(A) $4.7x10^{-25}$ (B) $7.8x10^{-9}$ (C) $4.5x10^{+48}$ (D) $2.2x10^{-49}$

45. The concentration of lead [Pb, M=207.2] in drinking water was determined using a concentration cell with 0.30 M lead(II) nitrate, $Pb(NO_3)_2$, in the reference cell (the cathode) and a sample of water with an unknown concentration of Pb^{2+}(xx) in the sample cell (the anode).
In cell notation, this can be written as: $Pb(s)|Pb^{2+}(xx)||Pb^{2+}(0.20\ M)|Pb(s)$.

The cell potential in the above concentration cell was measured to be +0.140 V. Therefore, the concentration of lead in the sample, in **milligrams per Liter (mg/L)** is approximately:

(A) 3.9 mg/L (B) 550 mg/L (C) 1.2 mg/L (D) $3.9x10^{-3}$ mg/L

46. The reaction for the reduction of O_2 in the environment and the reduction potetial for this reaction is given by: $O_2 + 2\ H_2O + 4\ e^{-} \rightarrow 4\ OH^{-}$ $E_{red}^{o}(O_2)$ = +0.40 V

Based upon electrochemical considerations, which of the following metals would be expected to corrode (i.e. undergo oxidation) in the presence of O_2 and H_2O? Ag, Sn, Cu, Hg

(A) Sn & Cu (B) Hg & Cu (C) Cu only (D) Ag & Hg

For #47 - #48: Use Table 2 (Some Reduction and Oxidation Potentials in Aqueous Solution) near the top of the test.

47. If aqueous Aluminum Iodide, AlI_3(aq) is placed in an electrolysis cell, and a voltage is applied, what will be the principal products of the electrolysis?

(A) Al , I_2 (B) Al , O_2 , H^{+}
(C) H_2 , OH^{-} , O_2 , H^{+} (C) I_2 , H_2 , OH^{-}

48. If aqueous Zn(II) Fluoride, ZnF_2(aq) is placed in an electrolysis cell, and a voltage is applied, what will be the principal products of the electrolysis?

(A) Zn , O_2 , H^{+} (B) Zn , F_2
(C) F_2 , H_2 , OH^{-} (C) H_2 , OH^{-} , O_2 , H^{+}

Version B

49. A total of 850 kJ of energy was required to plate out Al(s) [M=27.] by electrolysis of a $Al(NO_3)_3(aq)$ solution. The voltage was 8. Volts. Approximately how many grams of Al(s) were plated out by electrolysis?

(A) 89.2 g (B) 5.4 g (C) 9.9 g (D) 29.7 g

50. Approximately how long would it take to electroplate a metal surface with 0.15 g of Nickel [M=58.7] metal from a $Ni(NO_3)_2(aq)$ solution with a current of 150 mA (milliAmps)?

(A) 32.9 min (B) 157 min (C) 27.5 min (D) 54.8 min

51. What nuclide will undergo electron capture to form Pt-195 ?

(A) Ir-196 (B) Ir-195 (C) Pt-196 (D) Au-195

52. Which of the following decay paths is the most likely one for Rn-222 ?

(A) $^{222}_{86}Ra \rightarrow ^{0}_{+1}e + ^{222}_{85}At$ (B) $^{222}_{86}Ra \rightarrow ^{4}_{2}He + ^{218}_{84}Po$

(C) $^{222}_{86}Ra \rightarrow ^{0}_{-1}e + ^{222}_{87}Fr$ (D) $^{222}_{86}Ra + ^{0}_{-1}e \rightarrow ^{222}_{85}At$

53. Consider the nuclear reaction, $^{252}_{98}Cf + X \rightarrow 3\,^{1}_{0}n + ^{259}_{103}Lr$. What is X in this equation?

(A) $^{4}{}_{2}He$ (B) $^{10}{}_{5}B$ (C) $^{16}{}_{8}O$ (D) $^{8}{}_{5}B$

54. Which of the following is/are likely decay paths for Mg-22. Stable isotopes in this range typically have N/Z = 1.05.

(1) $^{22}_{12}Mg \rightarrow ^{0}_{-1}e + ^{22}_{13}Al$ (2) $^{22}_{12}Mg \rightarrow ^{0}_{+1}e + ^{22}_{11}Na$

(3) $^{22}_{12}Mg + ^{0}_{-1}e \rightarrow ^{22}_{11}Na$ (4) $^{22}_{12}Mg \rightarrow ^{4}_{2}He + ^{18}_{10}Ne$

(A) 1 & 4 (B) 4 only (C) 2 & 3 (D) 1 & 2

Two more MC questions on next page.

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55. Use the Molar Masses below to calculate the approximate Binding Energy per Nucleon (Eb/N) of Pb-208.

    m($_1^1H$) = 1.008 g/mol , m($_0^1n$) = 1.009 g/mol , m($_{82}^{208}Pb$) = 207.977 g/mol

    (A) 1.6×10^{14} kJ/mol
    (B) 7.8×10^{11} kJ/mol
    (C) 7.8×10^{8} kJ/mol
    (D) 1.6×10^{11} kJ/mol

56. One nuclear fusion reaction involves the reaction of a deuterium and tritium nucleus to form helium: $_1^2H + _1^3H \rightarrow _2^4He + _0^1n$. This reaction is highly exothermic because:

    (A) The n-n repulsions in deuterium and tritium are higher than in helium
    (B) Helium has a higher Binding Energy per nucleon than deuterium or tritium
    (C) The p-p attractions are greater in helium than in deuterium or tritoi,
    (D) Helium has a lower Binding Energy per nucleon than deuterium or tritium