

University of Kentucky

Department of Chemistry

READ THESE DIRECTIONS CAREFULLY BEFORE STARTING THE EXAMINATION!

It is *extremely* important that you fill in the answer sheet EXACTLY as indicated, otherwise your answer sheet may not be processed; ALL entries are to be made on SIDE 1 of the answer sheet. Use a #2 pencil (or softer); fill in the circles completely and firmly. Erasures must be complete. Use only the following categories:

NAME:	Print your name starting at the first space, LAST NAME first, then a space, followed by your FIRST NAME, then another space, followed by your MIDDLE INITIAL. Fill in the <u>correct</u> circles below your printed name corresponding to the letters of your name; for the spaces, fill in the top blank circle.
STUDENT NUMBER:	This is VERY IMPORTANT! Under IDENTIFICATION NUMBER, put in your 8 DIGIT STUDENT ID NUMBER (do not use the 9 at the beginning of your number) beginning in column A and continuing through column H, column I will be blank, (do NOT use column J at this time); be sure to fill in the correct circles (a common error to be avoided is mistaking "0" for "1").
TEST FORM:	Fill in the "4" blank in the J column under IDENTIFICATION NUMBER (to indicate Hour Examination IV).
SPECIAL CODES:	Use for course and section number; in positions K-P write in one of the following: <div style="display: flex; justify-content: space-between;"> <div style="text-align: center;">Dr. Soult</div> <div style="text-align: center;">107001 (10 am); 107002 (1 pm)</div> </div> <div style="display: flex; justify-content: space-between;"> <div style="text-align: center;">Dr. Blue</div> <div style="text-align: center;">107003 (11 am); 107006 (12:30 pm)</div> </div> <div style="display: flex; justify-content: space-between;"> <div style="text-align: center;">Dr. Ades</div> <div style="text-align: center;">107005</div> </div>
SIGNATURE:	You MUST sign the examination answer sheet (bubble sheet) on the line directly above your printed name. Use your legal signature.

Answering Questions:

Starting with answer "1" on SIDE 1, fill in the circle indicating the one best answer for each of the **60 questions** in this examination. Your score is the sum of the appropriate credit for each response.

Grading and Reporting:

The examination scores will be posted in Blackboard as soon as possible after the examination. If an error has occurred in scoring your answers, inform your instructor within 48 hours of the posting of your score.

BE SURE THAT YOUR TEST HAS 60 QUESTIONS, A PERIODIC TABLE, AND TWO SHEETS OF SCRATCH PAPER. You may **NOT** use your own scratch paper during this examination. Cell phones, computer, and pagers are to be turned off and out of sight during the exam. **All** exam paper, scratch paper, and scantrons must be handed in at the end of the exam. You may **not** take any exam materials away from the exam room.

Questions 1 – 16 cover Exam I material

1. Which of the following correctly lists the compounds in order of **increasing** strength of molecular forces?

A. H_2S , H_2O , NO

C. CH_3CH_3 , CO_2 , CH_4

B. CH_4 , H_2S , NH_3

D. NH_3 , HF , H_2S

2. Which one of the following has the species with the **higher** boiling point listed **second**?

A. NaCl , H_2O

C. H_2CO , C_2H_6

B. HCl , HF

D. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$, $\text{C}(\text{CH}_3)_4$

3. Bromine has a heat of vaporization of 15.4 kJ/mol and a normal boiling point of 58.8 °C (331.8 K). What is the vapor pressure of bromine at 25.0 °C (298 K)?

A. 403 torr

C. 654 torr

B. 835 torr

D. 328 torr

4. Which one of the following compounds has the **highest** vapor pressure at 25 °C?

A. $\text{C}_2\text{H}_5\text{OC}_2\text{H}_5$

C. H_2O

B. $\text{C}_2\text{H}_5\text{OH}$

D. $\text{HOCH}_2\text{CH}_2\text{OH}$

5. The enthalpy of sublimation of water at 0 °C is 54.15 kJ/mol. How much heat is needed to sublime 125.0 g of water at 0 °C? The molar mass of water is 18.02 g/mol.

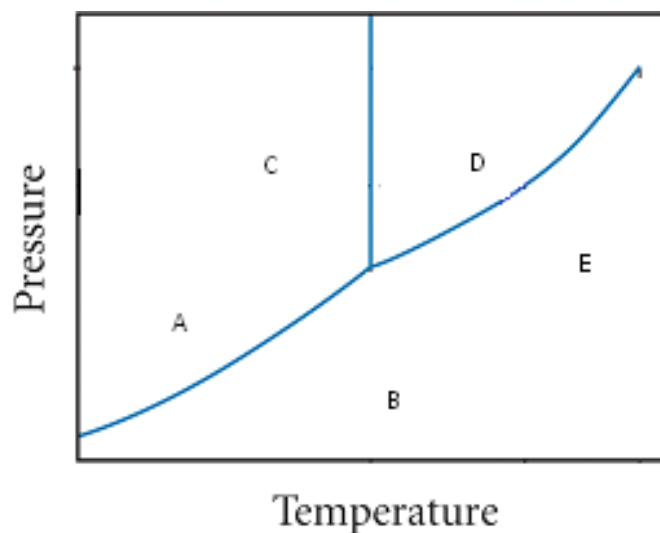
A. 23.04 kJ

C. 433.2 kJ

B. 375.6 kJ

D. 67.69 kJ

-
6. According to the phase diagram below, moving along a straight line from point _____ to point _____ would represent melting of the species?



- A. A to B
B. B to C
C. C to D
D. D to E
-
7. A crystalline unit cell contains halide atoms, X, on all six faces, and eight metal atoms, M, on all the corners of the cell. What is the correct formula for the ionic compound?

- A. M_4X_3
B. MX_6
C. M_2X_3
D. MX_3

-
8. What type of crystalline solid has a low melting point and is held together by dispersion forces only?

- A. metallic solid
B. network covalent solid
C. ionic solid
D. nonbonding atomic solid

-
9. Which of the following compounds is **most** soluble in hexane, C_6H_{14} ?

- A. H_2O
B. KI
C. CCl_4
D. NH_3
-

10. The solubility of $\text{Al}(\text{NO}_3)_3$ is 73.9 g per 100 g of water. If a student adds 35.9 g of $\text{Al}(\text{NO}_3)_3$ with stirring to 50.0 g of water, what type of solution will result?

- A. An unsaturated solution. C. A supersaturated solution.
B. A saturated solution. D. A supercritical solution.

11. The solubility of $\text{NH}_3(\text{g})$ in H_2O at 25 °C and 1.00 atm partial pressure of $\text{NH}_3(\text{g})$ is 58 mol/L. What is the solubility of $\text{NH}_3(\text{g})$ in H_2O at 25 °C at a partial pressure of NH_3 of 0.30 atm?

- A. 19 mol/L C. 52 mol/L
B. 0.52 mol/L D. 17 mol/L

12. A solution is prepared by adding 0.25 mol of ethanol (11.5 g or 14.6 mL) to 50.0 mL of water (density = 1.00 g/mL). Which one of the following will result in the concentration of the solution in units of molality?

- A. 11.5/0.050 C. 0.25/0.050
B. 11.5/0.064 D. 0.25/0.064

13. Find the ppb concentration for sucrose when 0.156 mg is dissolved in 725 g of water.

- A. 426 ppb C. 215 ppb
B. 1560 ppb D. 0.00527 ppb

14. What is the molarity of a 2.21 *m* CaCl_2 solution whose density is 1.03 g/mL?

- A. 1.83 M C. 2.78 M
B. 0.212 M D. 0.250 M
-

15. Which one of the following aqueous solutions has the **highest** boiling point?

A. 0.20 *m* C₆H₆O₁₂

C. 0.25 *m* CH₃OH

B. 0.10 *m* CaCl₂

D. 0.15 *m* Al(NO₃)₃

16. Calculate the osmotic pressure of 1.00 g MgCl₂ dissolved in enough water to make 125 mL of solution at 288 K. The molar mass of MgCl₂ is 95.2 g/mol.

A. 0.998 atm

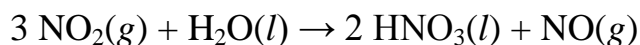
C. 25.9 atm

B. 5.96 atm

D. 2.69 atm

Questions 17 – 32 cover Exam II material

17. If NO₂(g) disappears at a rate of 0.900 M/s at a particular moment in the reaction below, what is the rate of appearance of HNO₃(l) at the same time?



A. 0.200 M/s

C. 1.90 M/s

B. 0.400 M/s

D. 0.600 M/s

18. A substance with an initial concentration of 4.50 M decomposes with second order kinetics. If the initial rate of the reaction is 0.0250 M/s, what is the value of the rate constant?

A. $1.41 \times 10^{-4} \text{ M}^{-1} \text{ s}^{-1}$

C. $0.0178 \text{ M}^{-1} \text{ s}^{-1}$

B. $0.503 \text{ M}^{-1} \text{ s}^{-1}$

D. $0.00123 \text{ M}^{-1} \text{ s}^{-1}$

-
19. The initial rate of the hypothetical reaction $A + B \rightarrow C$ was measured at several different concentrations of the reactants with the following results.

Experiment	[A] (M)	[B] (M)	Initial rate of formation of C (M/s)
1	0.10	0.020	1.5×10^{-4}
2	0.10	0.040	1.5×10^{-4}
3	0.20	0.020	6.0×10^{-4}

What is the experimental rate law for the reaction?

- A. $\text{rate} = k[A][B]^2$ C. $\text{rate} = k[B]^2$
B. $\text{rate} = k[A]^2$ D. $\text{rate} = k[A]^2 [B]$

-
20. The reaction $\text{NO}_2 + \text{CO} \rightarrow \text{NO} + \text{CO}_2$ is second-order in NO_2 , zero-order in CO , and has a rate constant of $0.245 \text{ M}^{-1}\text{s}^{-1}$. Starting with a concentration of 0.450 M NO_2 , what is the NO_2 concentration after 365 seconds?

- A. 0.0109 M C. 0.00324 M
B. 0.225 M D. 0.0239 M

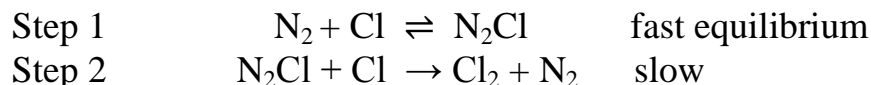
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21. Strontium-90 is radioactive and decays by a first-order process with a half-life of 28.0 yr. How much of a 0.500 mol sample of strontium is left after 99.0 years?

- A. 0.610 mol C. 0.00505 mol
B. 0.0311 mol D. 0.0431 mol

-
22. When the Kelvin temperature of a reaction is doubled, the value of the rate constant:

- A. doubles.
B. increases, but doesn't necessarily double.
C. decreases by half.
D. decreases, but not necessarily by half.
-

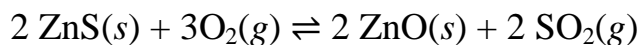
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23. The reaction $2 \text{Cl}(g) \rightarrow \text{Cl}_2(g)$ is known to be catalyzed by $\text{N}_2(g)$. The following mechanism has been proposed for the catalyzed reaction.



What is the rate law predicted by the mechanism?

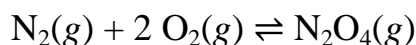
- A. $\text{rate} = k[\text{Cl}]^2$ C. $\text{rate} = k[\text{N}_2][\text{Cl}]^2$
B. $\text{rate} = k[\text{Cl}]$ D. $\text{rate} = k[\text{N}_2\text{Cl}]^2$

-
24. Which one of the following is the correct equilibrium constant, K_c , for the reaction below?

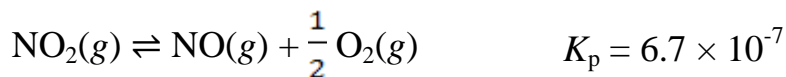
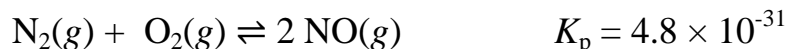


- A. $\frac{[\text{SO}_2]^2}{[\text{O}_2]^3}$ C. $\frac{2[\text{ZnO}] + 2[\text{SO}_2]}{2[\text{ZnS}] + 3[\text{O}_2]}$
B. $\frac{[\text{O}_2]^2}{[\text{SO}_2]^3}$ D. $\frac{[\text{ZnS}][\text{O}_2]^2}{[\text{ZnO}][\text{SO}_2]^3}$

-
25. What is the value of K_p at 298 K for the reaction

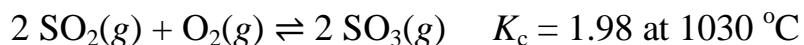


given the following data at 298 K?



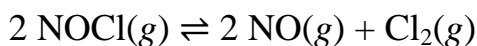
- A. $K_p = 7.1 \times 10^{-18}$ C. $K_p = 6.5 \times 10^{-10}$
B. $K_p = 3.2 \times 10^{-32}$ D. $K_p = 9.7 \times 10^{-14}$
-

-
26. Which way will the reaction proceed given the following initial concentrations: $[\text{SO}_2] = 0.50 \text{ M}$, $[\text{O}_2] = 2.00 \text{ M}$, and $[\text{SO}_3] = 0.50 \text{ M}$?



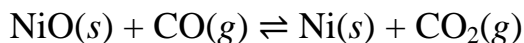
- A. To the left because $Q_c < K_c$ C. To the right because $Q_c < K_c$
B. To the left because $Q_c > K_c$ D. To the right because $Q_c > K_c$
-

27. What is the equilibrium concentration of NO given an initial concentration of 0.834 M NOCl and $K_c = 2.73 \times 10^{-8}$?



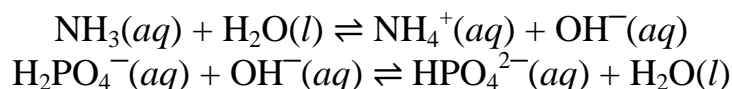
- A. $3.36 \times 10^{-3} \text{ M}$ C. $1.77 \times 10^{-3} \text{ M}$
B. $3.75 \times 10^{-3} \text{ M}$ D. $1.86 \times 10^{-3} \text{ M}$
-

28. What changes will increase the formation of nickel for the following exothermic reaction?



- A. Increasing temperature, addition of an inert gas, decreasing volume of reaction container.
B. Decreasing temperature and increasing the pressure of CO
C. Addition of inert gas and increasing volume of reaction container.
D. Increasing temperature and increasing the pressure of CO_2 .
-

29. Select the **reactants** from each balanced chemical equation that function as Brønsted-Lowry acids.



- A. $\text{NH}_3, \text{H}_2\text{PO}_4^-$ C. $\text{H}_2\text{O}, \text{H}_2\text{PO}_4^-$
B. NH_3, OH^- D. $\text{H}_2\text{O}, \text{OH}^-$
-

30. Find the pH of a solution containing 0.070 M HCl and 0.070 M HClO. K_a for HClO is 2.9×10^{-8} .

A. 0.65

C. 2.10

B. 1.15

D. 1.75

31. What is the pH of a 0.75 M weak acid solution that is 0.93% ionized?

A. 0.17

C. 2.16

B. 0.11

D. 0.75

32. The pH of an aqueous NH_3 solution is 11.00. What is the molarity of the ammonia solution? K_b for NH_3 is 1.8×10^{-5} .

A. 0.018 M

C. 0.0010 M

B. 0.65 M

D. 0.057 M

Questions 33 – 48 cover Exam III material

33. Which of the following will form the most basic solution in water?

A. 0.10 M $\text{C}_5\text{H}_5\text{NHCl}$

C. 0.10 M KI

B. 0.10 M Li_2S

D. 0.10 M KNO_3

34. What is the pH of a 1.35 M NH_4Cl solution? K_b of $\text{NH}_3 = 1.76 \times 10^{-5}$

A. 9.425

C. 2.231

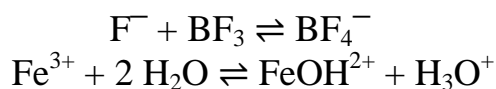
B. 4.558

D. 11.549

35. Which of the following lists the acids in order of increasing strength?



36. Identify the Lewis bases in the following reactions.



37. What is the pH of a buffer that has 0.423 M acetic acid and 0.471 M sodium acetate? K_a of acetic acid = 1.8×10^{-5} .

A. 4.79

C. 4.71

B. 4.92

D. 4.55

38. What is the pH of a solution after 5.00 ml of 0.20 M KOH is added to 20.0 mL of a buffer that is 0.40 M in HCHO_2 and 0.50 M in KCHO_2 ? K_a for HCHO_2 is 1.8×10^{-4} .

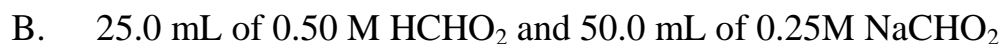
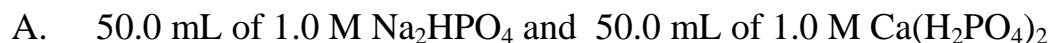
A. 7.60

C. 3.94

B. 4.28

D. 2.80

39. Which one of the following combinations will **not** act as an effective buffer?



40. What is the pH at the equivalence point when 25.0 mL of 0.50 M formic acid (monoprotic) is titrated with 35.7 mL of 0.35 M sodium hydroxide? K_a of formic acid = 1.8×10^{-4}

- A. 8.53
B. 6.81
C. 5.64
D. 7.99

41. A handbook lists the following information for some indicators:

Indicator	K_{HIn}	$\text{p}K_{\text{HIn}}$
bromocresol green	2.0×10^{-5}	4.70
phenolphthalein	4.0×10^{-10}	9.40
bromthymol blue	7.9×10^{-8}	7.10
thymol blue	2.0×10^{-2}	1.70

Which indicator would be **best** to use in the titration of 1.00 M acetic acid, $\text{HC}_2\text{H}_3\text{O}_2$, with 1.00 M potassium hydroxide, KOH? K_a for $\text{HC}_2\text{H}_3\text{O}_2 = 1.8 \times 10^{-5}$.

- A. bromocresol green
B. phenolphthalein
C. bromthymol blue
D. thymol blue

42. Calculate the molar solubility of PbBr_2 in pure water. The K_{sp} of PbBr_2 is 4.67×10^{-6} .

- A. 2.10×10^{-6} M
B. 6.95×10^{-4} M
C. 3.67×10^{-3} M
D. 1.05×10^{-2} M

43. Which of the following substances increases in solubility in water with a decrease in pH?

- A. PbCl_2
B. KNO_3
C. $\text{Cu}(\text{CN})_2$
D. AgBr
-

44. Two solutions are mixed together such that the final concentration of Ba^{2+} is $1.45 \times 10^{-3} \text{ M}$ and $\text{C}_2\text{O}_4^{2-}$ is $2.35 \times 10^{-4} \text{ M}$. The K_{sp} of BaC_2O_4 is 1.6×10^{-6} . Will a precipitate form?

- A. A precipitate will form because $Q > K_{\text{sp}}$.
- B. A precipitate will form because $Q < K_{\text{sp}}$.
- C. A precipitate will not form because $Q > K_{\text{sp}}$.
- D. A precipitate will not form because $Q < K_{\text{sp}}$.

45. What concentration of Zn^{2+} will remain when 200.0 mL of $4.50 \times 10^{-3} \text{ M Zn(NO}_3)_2$ is combined with 200.0 mL of 0.250 M NaOH? K_{f} of $\text{Zn(OH)}_4^{2-} = 2.0 \times 10^{15}$.

- A. $6.21 \times 10^{-15} \text{ M}$
- B. $8.80 \times 10^{-18} \text{ M}$
- C. $3.12 \times 10^{-12} \text{ M}$
- D. $4.29 \times 10^{-21} \text{ M}$

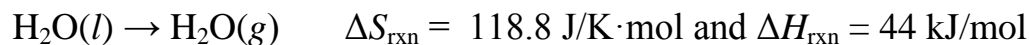
46. Which one of the following statements is true?

- A. An endothermic reaction always has a positive ΔS_{surr} .
- B. An endothermic reaction always has a positive ΔS_{sys} .
- C. An exothermic reaction always has a positive ΔS_{surr} .
- D. An exothermic reaction always has a positive ΔS_{sys} .

47. Which of the following will have a positive change in the entropy of the system?

- A. $2 \text{ SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2 \text{ SO}_3(\text{g})$
 - B. $\text{CO}(\text{g}) + 2 \text{ H}_2(\text{g}) \rightarrow \text{CH}_3\text{OH}(\text{l})$
 - C. $2 \text{ NO}(\text{g}) \rightarrow \text{N}_2(\text{g}) + \text{O}_2(\text{g})$
 - D. $\text{FeCl}_2(\text{s}) + \text{H}_2(\text{g}) \rightarrow \text{Fe}(\text{s}) + 2 \text{ HCl}(\text{g})$
-

48. Consider the reaction below:



What is the entropy change for the **universe** at 25 °C for the reaction?

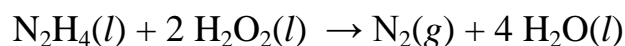
- A. 74.8 J/K
B. -4520J/K
C. -28.8 J/K
D. 67.5 J/K

Questions 49 – 60 cover material after Exam III

49. Given $\Delta H = 342 \text{ kJ/mol}$ and $\Delta S = 143 \text{ J/mol}\cdot\text{K}$, what is ΔG at 308 K?

- A. 336 kJ/mol
B. 298 kJ/mol
C. -463 kJ/mol
D. -437 kJ/mol

50. Using the data below, calculate the standard entropy change for the following reaction.



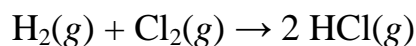
Substance	$S^\circ \text{ (J/K}\cdot\text{mol)}$
$\text{N}_2\text{H}_4(l)$	121.2
$\text{H}_2\text{O}_2(l)$	109.6
$\text{N}_2(g)$	191.6
$\text{H}_2\text{O}(l)$	188.8

- A. 611.2 J/K
B. 606.4 J/K
C. -149.6 J/K
D. 750.4 J/K

51. Predict the spontaneity and temperature dependence of a reaction if the sign of ΔH is positive and the sign of ΔS is positive.

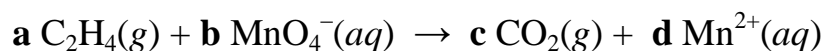
- A. The reaction will be spontaneous at all temperatures.
B. The reaction will be spontaneous at low temperature, but nonspontaneous at high temperature.
C. The reaction will be nonspontaneous at all temperatures.
D. The reaction will be nonspontaneous at low temperature, but spontaneous at high temperature.
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52. One mole of hydrogen and one mole of chlorine are initially placed in a 1.0 L container. After reaching equilibrium, there are 0.0200 moles each of hydrogen and chlorine and 1.96 moles of HCl. What is the value of the standard free energy at 25°C once equilibrium has been established?



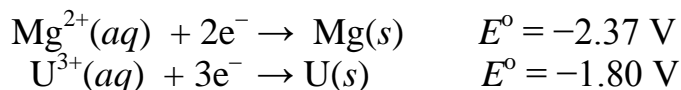
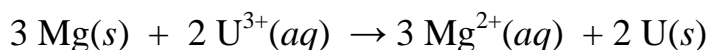
- A. -23 kJ/mol
B. -8.7 kJ/mol
C. -17 kJ/mol
D. -162 kJ/mol

-
53. What is the coefficient **a** when the reaction below is balanced in acid?



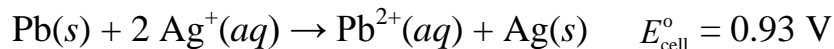
- A. 2
B. 5
C. 8
D. 12

-
54. Using the standard reduction potentials listed below, calculate the E°_{cell} at 25°C for



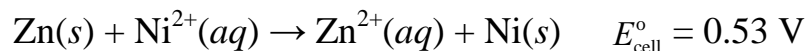
- A. 0.57 V
B. 4.17 V
C. -3.51 V
D. -0.75 V

-
55. Calculate the equilibrium constant, K , at 25°C (298 K) for



- A. 3.1×10^{12}
B. 1.8×10^{-2}
C. 2.6×10^{31}
D. 5.2×10^{45}
-

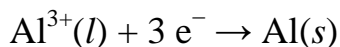
56. A voltaic cell is constructed that uses the following reaction



What is E_{cell} when $[\text{Ni}^{2+}] = 0.200 \text{ M}$ and $[\text{Zn}^{2+}] = 0.900 \text{ M}$ at 25°C (298 K)?

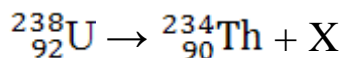
- A. 0.53 V
B. 0.49 V
C. 0.51 V
D. 0.57 V

57. What mass of aluminum can be plated out of a molten $\text{AlCl}_3(l)$ solution by a $1.80 \times 10^3 \text{ s}$ flow of 5.00 A current?



- A. 1.20 g
B. 0.258 g
C. 2.58 g
D. 0.839 g

58. What is X in the following nuclear reaction?



- A. Positron
B. Beta particle
C. Gamma ray
D. Alpha particle

59. Which one of the following isotopes will be **most** likely to undergo radioactive decay?

- A. Rb-86
B. Si-28
C. Y-89
D. Mn-55

60. How much of a 2.00 g sample of radon-220 remains after 222.4 seconds given the half-life of radon-220 is 55.6 seconds?

- A. 0.00365 g
B. 1.75 g
C. 0.125 g
D. 0.0168 g
-

CHE 107 SPRING 2013 Final Exam Key

1. B
2. B
3. A
4. A
5. B
6. C
7. D
8. D
9. C
10. A
11. D
12. C
13. C
14. A
15. D
16. B
17. D
18. D
19. B
20. A
21. D
22. B
23. C
24. A
25. A
26. C
27. A
28. B
29. C
30. B
31. C
32. D
33. B
34. B
35. A
36. B
37. A
38. C
39. D
40. A
41. B
42. D
43. C
44. D
45. A
46. C
47. D
48. C
49. B
50. B

- 51. D
- 52. A
- 53. B
- 54. A
- 55. C
- 56. C
- 57. D
- 58. D
- 59. A
- 60. C