

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="text-align: center;"> <table> <tr> <td>Dr. Ades</td> <td>107-001 (MWF), put 107001</td> </tr> <tr> <td></td> <td>107-002 (TR), put 107002</td> </tr> <tr> <td>Dr. Selegue</td> <td>107003</td> </tr> </table> </div>	Dr. Ades	107-001 (MWF), put 107001		107-002 (TR), put 107002	Dr. Selegue	107003
Dr. Ades	107-001 (MWF), put 107001						
	107-002 (TR), put 107002						
Dr. Selegue	107003						
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 – 15 cover Exam I material

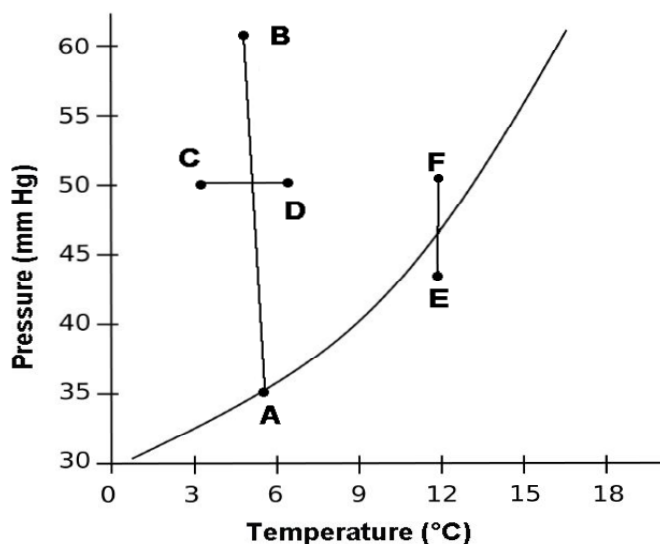
1. What type(s) of forces is (are) present in CH_3OH in the condensed phase?

- A. dispersion only
 - B. dispersion and dipole-dipole
 - C. dispersion, dipole-dipole, and hydrogen bonding
 - D. ion-dipole
-

2. Which is the weakest of these interparticle forces?

- A. cation-anion attraction
 - B. hydrogen bonding
 - C. dispersion (London) forces
 - D. dipole-dipole attractions
-

3. Which statement is true about the partial phase diagram of benzene (C_6H_6) below?



- A. The slope of the line A–B implies that liquid C_6H_6 is denser than solid C_6H_6 .
 - B. Moving from point C to point D describes melting of C_6H_6 (s) at constant pressure.
 - C. Point A is the critical point of C_6H_6 .
 - D. Moving from point E to point F describes sublimation of C_6H_6 (s) at low pressure.
-

4. For water, which is the most exothermic process?

- A. Sublimation of $\text{H}_2\text{O} (s)$ to $\text{H}_2\text{O} (g)$ C. Condensation of $\text{H}_2\text{O} (g)$ to $\text{H}_2\text{O} (l)$
B. Melting $\text{H}_2\text{O} (s)$ to $\text{H}_2\text{O} (l)$ D. Freezing of $\text{H}_2\text{O} (l)$ to $\text{H}_2\text{O} (s)$
-

5. How much heat (in kJ) is released when 5.00 moles of water at $75\text{ }^\circ\text{C}$ are converted to ice at $-75\text{ }^\circ\text{C}$?

$$\Delta H_{\text{fus}} = 6.02 \text{ kJ/mol}$$

$$\Delta H_{\text{vap}} = 40.7 \text{ kJ/mol}$$

specific heat capacities:

$$C_s(\text{ice}) = 2.09 \text{ J/g}\cdot^\circ\text{C}$$

$$C_s(\text{liquid water}) = 4.18 \text{ J/g}\cdot^\circ\text{C}$$

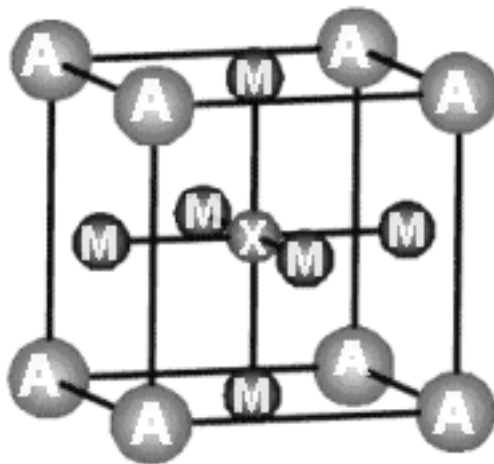
$$C_s(\text{steam}) = 2.01 \text{ J/g}\cdot^\circ\text{C}$$

- A. 72.4 kJ C. 156.7 kJ
B. 37.8 kJ D. 78.4 kJ
-

6. What is the vapor pressure of water at $95\text{ }^\circ\text{C}$? ΔH_{vap} of water is 40.7 kJ/mol and the boiling point is $100\text{ }^\circ\text{C}$.

- A. 636 mmHg C. 478 mmHg
B. 768 mmHg D. 296 mmHg
-

-
7. A solid crystallizes in the unit cell shown below. What is the empirical formula of the material?



- A. AMX
B. A₈M₆X
C. A₄M₃X
D. AM₃X
-
8. Iridium (Ir) crystallizes in a face-centered cubic cell with an edge length of 383.3 pm. What is the density of iridium?

- A. 12.46 g/cm³
B. 22.67 g/cm³
C. 8.788 g/cm³
D. 3.456 g/cm³

-
9. KCl (*s*) does not dissolve in CCl₄ (*l*) because

- A. dipole-dipole interactions in pure CCl₄ are very strong.
B. ion-ion attractions between K⁺ and Cl⁻ are very weak.
C. dissolving a solid requires hydrogen-bonding interactions.
D. ion-dipole attractions between CCl₄ and K⁺ or Cl⁻ are very weak.
-

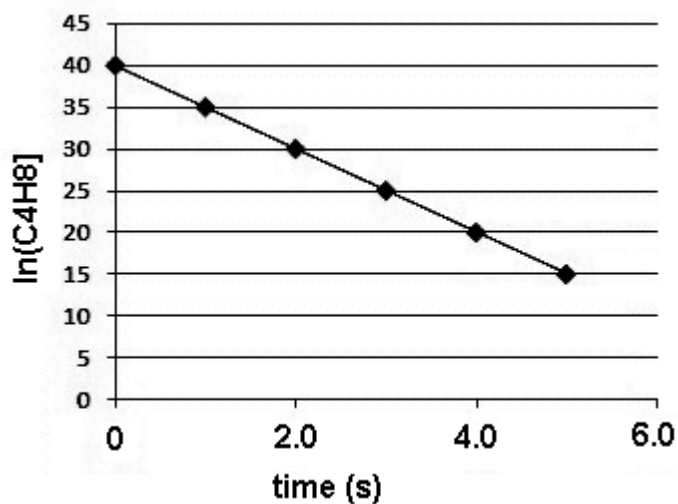
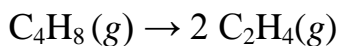
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10. The solubility of $\text{NH}_3(g)$ in H_2O at 25°C and 1.00 atm partial pressure of $\text{NH}_3(g)$ is 58 mol/L. What is the solubility of $\text{NH}_3(g)$ in H_2O at a partial pressure of NH_3 of 0.20 atm?
- A. 29 mol/L
B. 5.8 mol/L
C. 2.9 mol/L
D. 12 mol/L
-
11. Determine the molality of NaBr (molar mass = 103.0 g/mol) in an aqueous solution that is 34.0% NaBr by mass.
- A. 2.62 *m*
B. 3.97 *m*
C. 5.00 *m*
D. 7.69 *m*
-
12. A 16.0 M aqueous nitric acid (HNO_3) solution has a density of 1.42 g/mL. What is the molality of the solution? The molar mass of HNO_3 is 63.0 g.
- A. 71.0 *m*
B. 13.3 *m*
C. 38.8 *m*
D. 23.9 *m*
-
13. What is the vapor pressure at 60°C , of a solution containing 3.00×10^2 g of nonvolatile urea, $(\text{NH}_2)_2\text{CO}$ (molar mass 60.0 g/mol), in 4.50×10^2 g of water? The vapor pressure of pure water at 60°C is 129.3 mmHg.
- A. 2.59 mmHg
B. 132 mmHg
C. 115 mmHg
D. 108 mmHg
-
14. The boiling point of an aqueous sucrose solution is 100.39°C . What mass of sucrose (molar mass = 342.30 g/mol) was dissolved in 500.0 g of water to make this solution? $K_b(\text{water}) = 0.512^\circ\text{C}/m$
- A. 130. g sucrose
B. 223 g sucrose
C. 528 g sucrose
D. 762 g sucrose
-

-
15. Catalase, a liver enzyme, is water-soluble. A 10.0-mL solution containing 0.166 g of catalase has an osmotic pressure of 1.20 mmHg at 20 °C. What is the molar mass of catalase?
- A. 2.53×10^5 g/mol
B. 6.35×10^4 g/mol
C. 1.25×10^{-3} g/mol
D. 3.44×10^6 g/mol
-

Questions 16 – 30 cover Exam II material

16. The reaction
 $2 \text{NO}_2(g) + \text{Cl}_2(g) \rightarrow 2 \text{NO}_2\text{Cl}(g)$
proceeds at a rate such that $\Delta[\text{NO}_2\text{Cl}]/\Delta t = 0.30$ M/s.
At the same time, what is the rate at which Cl_2 is reacting?
- A. 0.30 M/s
B. 0.15 M/s
C. 0.60 M/s
D. 0.45 M/s
-
17. The reaction
 $\text{A}(g) + \text{B}(g) \rightarrow \text{C}(g)$
is second order in A and first order in B. What is the effect on the rate when the concentrations of A and B are both tripled?
- A. The rate increases by a factor of 9.
B. The rate increases by a factor of 12.
C. The rate increases by a factor of 27.
D. The rate increases by a factor of 36.
-
18. Which of these statements is characteristic of a **first order** reaction having only one reactant?
- A. The rate of the reaction is not dependent on the concentration of the reactant.
B. The rate of the reaction is proportional to the square of the concentration of the reactant.
C. The rate of the reaction is proportional to the natural logarithm of the concentration of the reactant.
D. The rate of the reaction is directly proportional to the concentration of the reactant.
-

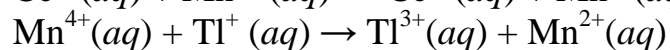
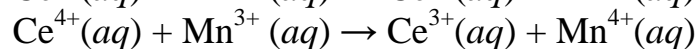
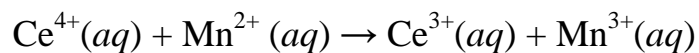
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19. The plot below shows the decomposition of cyclobutane to ethene as a function of time. What is the rate law for this reaction?



- A. Rate = $1.6 \text{ M}\cdot\text{s}^{-1}$ C. Rate = $(5.0 \text{ s}^{-1})[\text{C}_4\text{H}_8]$
B. Rate = $(5.0 \text{ M}^{-1}\cdot\text{s}^{-1})[\text{C}_4\text{H}_8]^2$ D. Rate = $(150 \text{ s}^{-1})[\text{C}_4\text{H}_8]$
-
20. Reactions generally proceed faster at higher temperature because
- A. activation energy decreases at higher temperature.
B. rate constants increase at higher temperature.
C. molecules move more slowly at higher temperature.
D. the orientation factor is lower at higher temperature.
-
21. Radioactive iodine-137 has a half-life of 24.13 s. How long will it take for a 75.0 g sample of ^{137}I to decay to 10.0 g? Radioactive decay follows first-order kinetics.

- A. 70.2 s C. 50.2 s
B. 73.3 s D. 75.0 s
-

-
22. The following mechanism has been proposed for a reaction that occurs in aqueous solution.



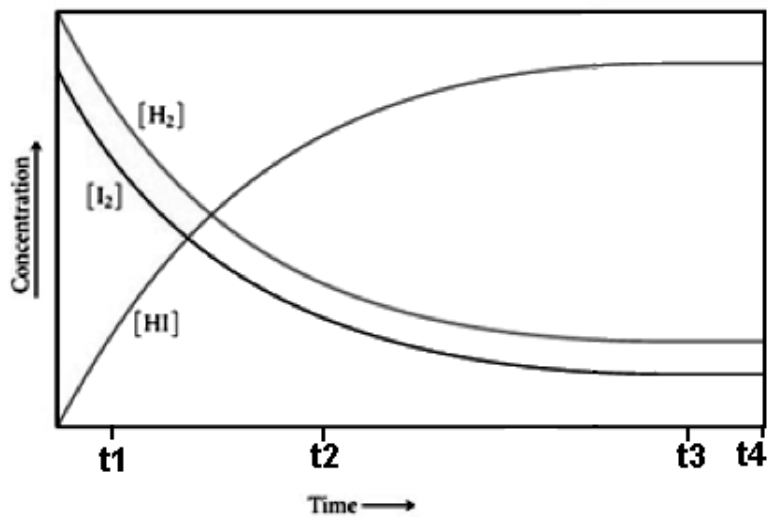
Which one of the following ions is a catalyst for the reaction?

- A. $\text{Mn}^{3+}(\text{aq})$
- B. $\text{Tl}^{3+}(\text{aq})$
- C. $\text{Ce}^{3+}(\text{aq})$
- D. $\text{Mn}^{2+}(\text{aq})$

-
23. A reversible reaction has an activation energy in the forward direction of 45.0 kJ/mol and in the reverse direction of 154 kJ/mol. What is ΔH_{rxn} for the **forward** reaction?

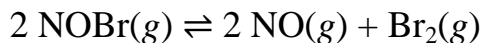
- A. -199 kJ/mol
 - B. -109 kJ/mol
 - C. 109 kJ/mol
 - D. 199 kJ/mol
-

-
24. The plot below follows the reaction
 $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2 \text{HI}(\text{g})$
as a function of time. Which statement is true?

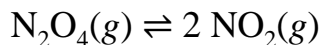


- A. At time t_1 , the system is at equilibrium.
B. At time t_2 , the rate of formation of HI is increasing.
C. At time t_3 , $-\Delta[\text{H}_2]/\Delta t = \frac{1}{2}\Delta[\text{HI}]/\Delta t$.
D. After time t_4 , $[\text{HI}]$ will continue to increase.
-
25. At 700 K
- $K_p = 1.85 \times 10^{-2}$ for $2 \text{HI}(\text{g}) \rightleftharpoons \text{H}_2(\text{g}) + \text{I}_2(\text{g})$
and $K_p = 9.62 \times 10^3$ for $2 \text{NH}_3(\text{g}) \rightleftharpoons \text{N}_2(\text{g}) + 3 \text{H}_2(\text{g})$
- What is K_p for $6 \text{HI}(\text{g}) + \text{N}_2(\text{g}) \rightleftharpoons 2 \text{NH}_3(\text{g}) + 3 \text{I}_2(\text{g})$ at 700 K?
- A. 5.53×10^{-2}
B. 2.54×10^3
C. 6.58×10^{-10}
D. 6.25×10^5
-

-
26. At 298 K K_p for the reaction below is 12.2. The reaction starts with a mixture of NOBr, NO, and Br₂ at partial pressures 1.00 atm, 1.00 atm, and 5.00 atm, respectively. Which one of the following statements is true at equilibrium at 298 K?



- A. At equilibrium the total pressure will be equal to the initial total pressure (7.00 atm).
B. At equilibrium the total pressure will be less than the initial total pressure (7.00 atm).
C. Not enough information is given to solve the problem.
D. At equilibrium the total pressure will be greater than the initial total pressure (7.00 atm).
-
27. For the reaction



$K_C = 0.21$ at a particular temperature. If $[\text{N}_2\text{O}_4]_{\text{eq}} = 0.039 \text{ M}$, determine the equilibrium concentration of $\text{NO}_2(g)$.

- A. 11 M
B. $9.0 \times 10^{-2} \text{ M}$
C. $8.2 \times 10^{-3} \text{ M}$
D. $6.7 \times 10^{-5} \text{ M}$
-
28. Which change will cause this reaction at equilibrium to shift to the right (in the direction of product)?



- A. Increasing the volume of the container holding the reaction mixture
B. Increasing the amount of $\text{MgO}(s)$ present
C. Increasing the temperature
D. Increasing the pressure of $\text{CO}_2(g)$
-

29. What is the pH of a 0.050 M aqueous solution of KOH?

- A. 12.70
B. 5.70
C. 8.30
D. 1.30

30. Which of the following statements is false for a 0.0010 M aqueous HCN solution?

- A. $\text{pH} < 3.0$
B. $[\text{H}_3\text{O}^+] = [\text{CN}^-]$
C. $[\text{HCN}] > [\text{H}_3\text{O}^+]$
D. $[\text{OH}^-] < [\text{H}_3\text{O}^+]$

Questions 31 – 45 cover Exam III material

31. What is the concentration of an aqueous HI solution with $\text{pH} = 4.52$?

- A. $1.1 \times 10^{-2} \text{ M}$
B. $4.5 \times 10^{-4} \text{ M}$
C. $3.0 \times 10^{-5} \text{ M}$
D. $3.3 \times 10^{-5} \text{ M}$

32. What is the pH of an aqueous mixture that is 0.50 M in HI and 0.050 M in HNO_3 ?

- A. 1.30
B. The K_a of HNO_3 is needed to answer the question.
C. 0.26
D. 0.33

33. What is the pH of a 0.025 M aqueous solution of methylammonium chloride, $(\text{CH}_3\text{NH}_3\text{Cl})$? K_b of methylamine, CH_3NH_2 , is 4.4×10^{-4} .

- A. 1.60
B. 6.12
C. 7.88
D. 12.23
-

34. Which of these salts dissolves in water to give a 0.1 M solution in the indicated pH range?

- A. KF, pH > 7
- B. Ca(CN)₂, pH < 7
- C. NH₄Cl, pH = 7
- D. NaClO₄, pH > 7

35. Which pair has the stronger acid listed first?

- A. H₂O > HF
- B. HS⁻ > H₂S
- C. HClO₃ > HClO₂
- D. [K(H₂O)₆]⁺ > [Al(H₂O)₆]³⁺

36. Choose the effective pH range of a formic acid-sodium formate (HCHO₂/NaCHO₂) buffer. *K_a* of HCHO₂ is 1.8×10^{-4} .

- A. 2.7–4.7
- B. 1.7–5.7
- C. 9.3–11.3
- D. 8.3–12.3

37. What is the pH of an aqueous solution that is 0.20 M in pyridine (C₅H₅N) and 0.50 M in pyridinium chloride (C₅H₅NHCl)? *K_b* of pyridine is 1.7×10^{-9} .

- A. 8.77
- B. 5.63
- C. 8.37
- D. 4.83

38. Calculate the pH of 1.00 L of a buffer that contains 1.00 mol of formic acid (HCHO₂) and 1.00 mol of sodium formate (NaCHO₂) after 0.100 mol of HNO₃ is added to the buffer. *K_a* for formic acid is 1.8×10^{-4} .

- A. 3.66
 - B. 3.83
 - C. 3.72
 - D. 3.58
-

39. A 1.00 L buffer solution is 0.10 M in NH_3 and 0.20 M in NH_4Cl . Which action will destroy the buffer?

A. adding 0.10 mol NH_3

C. adding 0.050 mol NH_4Cl

B. adding 0.05 mol HCl

D. adding 0.30 mol NaOH

40. What is the pH of the solution that results when 25.0 mL of 0.100 M HCl is titrated with 12.5 mL of 0.200 M CH_3NH_2 ? K_b for CH_3NH_2 is 4.4×10^{-4} .

A. 8.18

C. 5.91

B. 3.36

D. 10.64

41. Which is **not** an important requirement for an indicator (HIn) to signal the endpoint of the titration of a weak acid with a strong base?

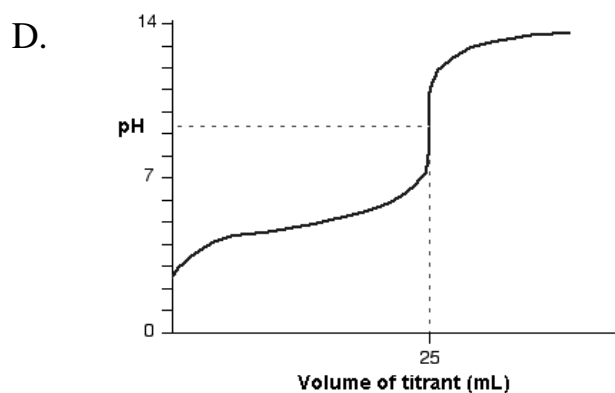
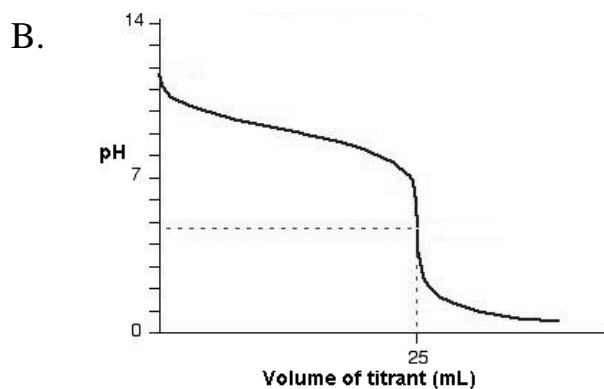
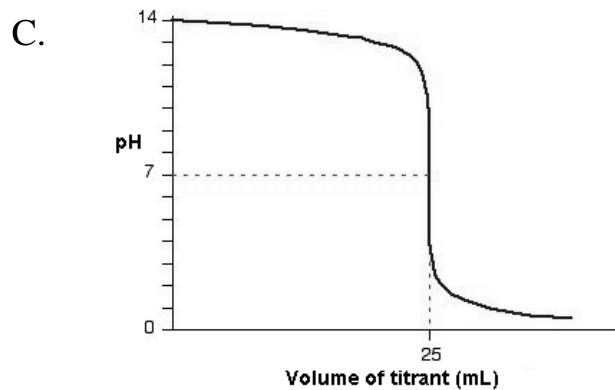
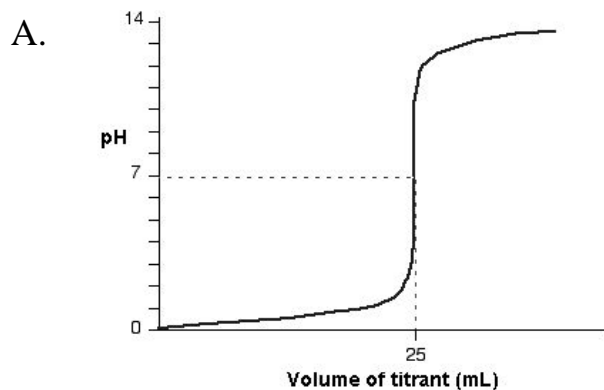
A. $\text{p}K_a$ of the acid form of the indicator (HIn) > 7.0 .

B. Brightly colored in both its acid (HIn) and base (In^-) form.

C. $\text{p}K_a$ of the acid form of the indicator (HIn) close to the equivalence point of the titration.

D. Soluble in water.

42. Which plot shows the titration of a weak acid with a strong base?



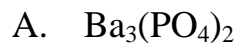
43. Each of two salts, AX and MZ_2 , has $K_{sp} = 1.0 \times 10^{-10}$. Which statement is true?

- A. AX and MZ_2 have the same molar solubility.
- B. MZ_2 has a greater molar solubility than AX.
- C. AX has a greater molar solubility than MZ_2 .
- D. AX and MZ_2 are both highly soluble.

44. What is the molar solubility of $Co(OH)_2$ at a pH of 8.00? K_{sp} for $Co(OH)_2$ is 5.9×10^{-15} .

- A. $5.9 \times 10^{-5} M$
 - B. $5.9 \times 10^{-3} M$
 - C. $5.9 \times 10^{-7} M$
 - D. $5.9 \times 10^{-9} M$
-

45. Which one of the following compounds is more soluble in acid solution than in pure water?



Questions 46 – 60 cover material after Exam III

46. Which statement is TRUE?

A. Entropy is an intensive property.

B. Entropy is not temperature dependent.

C. Exothermic processes increase the entropy of the surroundings.

D. $\Delta S_{\text{universe}} < 0$ for a spontaneous process.

47. Which one of the following has a positive entropy change?

A. water freezing

C. forming $\text{NH}_3(l)$ from $\text{N}_2(g)$ and $\text{H}_2(g)$

B. I_2 subliming

D. steam condensing

48. Which pair has the system with greater standard molar entropy listed first?

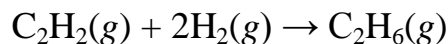
A. $\text{C}_2\text{H}_4(g) > \text{CH}_4(g)$

C. $\text{F}_2(g) > \text{Cl}_2(g)$

B. $\text{SO}_3(s) > \text{SO}_2(g)$

D. $\text{C}(\text{diamond}) > \text{C}(\text{graphite})$

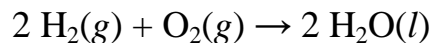
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49. Calculate $\Delta S^\circ_{\text{rxn}}$ for the following reaction. S° for each species is shown below the reaction.



Substance	S° (J/mol·K)
$\text{C}_2\text{H}_2(g)$	201
$\text{H}_2(g)$	131
$\text{C}_2\text{H}_6(g)$	229

- A. +103 J/K
B. +28 J/K
C. -103 J/K
D. -234 J/K

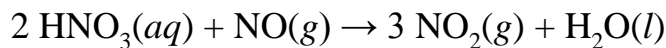
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50. The reaction



has $\Delta H_{\text{rxn}} = -571.5 \text{ kJ}$ and $\Delta S_{\text{rxn}} = -326.3 \text{ J/K}$. What is the maximum work that can be done by the reaction at 298 K?

- A. -571.5 kJ
B. -460.7 kJ
C. -326.3 kJ
D. -474.3 kJ

-
51. Above what temperature is this reaction spontaneous?



$$\Delta H^\circ_{\text{rxn}} = +136 \text{ kJ}$$
$$\Delta S^\circ_{\text{rxn}} = +288 \text{ J/K}$$

- A. 2.12 K
B. 472 K
C. This reaction is nonspontaneous at all temperatures.
D. This reaction is spontaneous at all temperatures.
-

52. At 1 atm pressure, the exothermic reaction $2 \text{Cl}(g) \rightarrow \text{Cl}_2(g)$ is

- A. spontaneous at all temperatures. C. spontaneous only at low temperatures.
B. never spontaneous. D. spontaneous only at high temperatures.
-

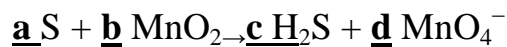
53. The equilibrium constant for
 $2\text{NO}_2(g) \rightleftharpoons \text{N}_2\text{O}_4(g)$
is 10.0 at 25 °C. What is ΔG° for this reaction?

- A. -5.70 kJ C. +0.960 kJ
B. -0.960 kJ D. +5.70 kJ
-

54. $\Delta G^\circ = 91.4 \text{ kJ}$ at 25 °C for the reaction
 $\text{C}(s) + \text{H}_2\text{O}(g) \rightarrow \text{CO}(g) + \text{H}_2(g)$.
What is ΔG at 25 °C when the partial pressures of CO, H₂, and H₂O are all 2.00 atm?

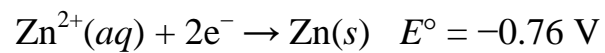
- A. 17.2 kJ C. 87.9 kJ
B. 93.1 kJ D. 96.3 kJ
-

55. What is the coefficient **c** when the following redox reaction is balanced according to convention in acidic solution?



- A. 1 C. 3
B. 2 D. 4
-

59. Which of the following is the strongest reducing agent?



- A. Fe(s)
- B. Zn(s)
- C. $\text{Zn}^{2+}(\text{aq})$
- D. $\text{Fe}^{2+}(\text{aq})$

60. What is produced at the anode in the electrolysis of molten AlCl_3 ?

- | | |
|-------|--------------------|
| A. Al | C. Al^{+} |
| B. Cl | D. Cl_2 |
-

CHE 107 FALL 2012 Final Exam Key

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

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