

CHEM 1211 and CHEM 1212 National ACS Exams

About the Exam Requirement

The Augusta University CHEM 1211 and 1212 Principles of Chemistry courses follow a common model for course content and use national exams from the American Chemical Society (ACS). These exams help validate course quality and ensure students are ready to succeed in subsequent coursework. In fact, the catalog specifies meeting the standard on these exams as a prerequisite for the next course, including transfer or transient courses.

What am I supposed to do?

CHEM 1211 or 1212 at Augusta University:

If you take these courses at AU, you must meet the departmental standard on the exam to earn a C or better in the course. If you earned a C or better, there is no further action necessary and you meet the prerequisite for the next course (CHEM 1211 → CHEM 1212 or CHEM 1212 → CHEM 3411)

CHEM1211 or 1212 level course at another institution

If you have taken the introductory chemistry course at another institution as a transfer or transient, your course will transfer as CHEM A, and not automatically as CHEM 1211 or 1212. You have 3 possible actions.

1. *No further chemistry courses planned:* If you will not be taking additional chemistry courses, the CHEM A will count as elective credit. If you need it to count in the Core Curriculum, bring the course substitution approval form to the Department of Chemistry and Physics.
2. *Use ACS exam from other institution:* If you plan to take the next chemistry course, and you already took the ACS exam at your previous institution, you may ask your professor to send the exam score, specifying test version, to the Department of Chemistry and Physics at Augusta University. With a suitable score, the transfer will be updated from CHEM A to CHEM 1211 or 1212 as appropriate and you will meet the prerequisite for the next course.
3. *Take ACS exam here:* If you didn't take the ACS exam already, or are unable to have the score sent, you may complete the exam here free of charge. You must contact the Department of Chemistry and Physics (706-737-1541) to schedule a time during business hours 8-5 M-F. With a suitable score, the transfer will be updated from CHEM A to CHEM 1211 or 1212 as appropriate and you will meet the prerequisite for the next course.

How should I prepare for the exam?

The ACS publishes a study guide (ISBN 0-9708042-0-2) that is available in the bookstore: *Preparing for Your ACS Examination in General Chemistry*. It contains 10 chapters organized by topic that cover both CHEM 1211 and CHEM 1212 material.

The CHEM 1211 course covers the following broad topics, and the exam is conceptual to determine fundamental understanding of concepts.

- Atomic Structure
- Molecular Structure and Bonding
- Stoichiometry

- States of Matter and Intermolecular Forces
- Periodicity

The CHEM 1212 course reinforces and builds upon the 1211 topics and further covers the additional topics below. While the test requires understanding of topics, the test is less conceptual.

- Solutions
- Energetics
- Dynamics
- Equilibrium
- Electrochemistry/Redox

As the published ACS Study Guide articulates, chemistry knowledge should be more than sets of formulas and techniques. Rather, it is a coherent set of knowledge that enables comprehension of the submicroscopic (chemical) world. As such, the ACS tests seek to uncover such genuine understanding.

CHEM 1211 Example Questions

There is an emphasis on conceptual questions. The actual exam will be multiple choice. The below questions are guaranteed not to be on the exam.

Atomic Structure

1. How many protons, neutrons and electrons are in each of the following?



2. Match the quantum number (column 1) with what it represents (column 2).

There may be more than one answer in column two that is correct and column 2 answers may be used more than once or not at all.

Column 1	Column 2
Principal (n)	Number of nodes
Angular momentum (l)	Shape of orbital
Magnetic (m _l)	Size of orbital (distance orbital extends from the nucleus)
Spin (m _s)	Degenerate energies
	Increasing potential energy
	Direction electron is spinning

3. Elemental iodine is a purple solid with naturally occurring iodine having the properties shown in the table.

Property	
Melting point	114 degrees C

Solubility	Soluble in hexane, poorly soluble in water
Reactivity	Oxidizing agent
Formula weight (or molecular mass)	254 g/mol

Which properties will have a significant, noticeable change when the iodine has each adjustment below:

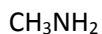
- A neutron is removed from each iodine atom
- A proton is removed from each iodine atom
- An electron is removed from the iodine molecule

4. Name 2 experiments that support the idea that electrons have particle-wave duality.

Molecular Structure and bonding

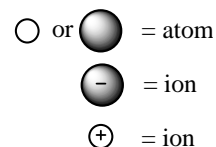
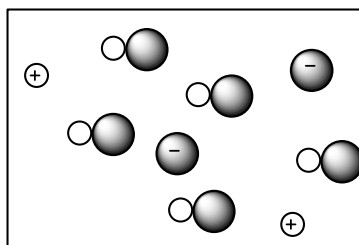
1. For each of the following formulas:

- if ionic, write the formulas of the ions; if covalent, draw the Lewis structure
- For each covalent compound, describe the electronic and molecular geometry
- For each covalent compound, describe the hybridization of the central atom
- Name each compound, except the organic one.
- How many sigma and how many pi bonds does each compound have?

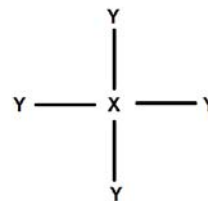
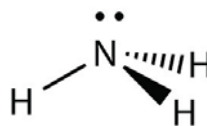
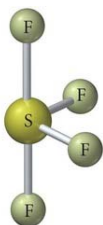


2. Consider the representation of a substance dissolved in water (water fills the box but is not shown). What best describes this substance?

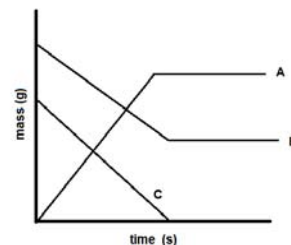
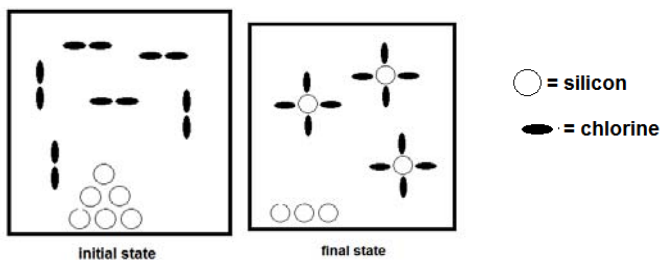
- it is a covalent, non-electrolyte
- it is a covalent, strong electrolyte
- it is a covalent, weak electrolyte
- it is soluble ionic compound
- it is an insoluble ionic compound



3. Identify each geometry shown below. What hybridization does each represent?



Stoichiometry



All questions refer to the boxes above which represent a chemical reaction.

_____ 1. What is the chemical formula of the limiting reactant?

_____ 2. What is the chemical formula of the product?

3. The graph on the right describes what happens to the various components of the reaction over time. Write the chemical formula of the component described by each line.

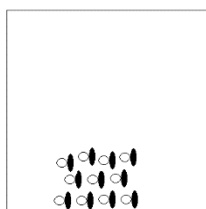
_____ A

_____ B

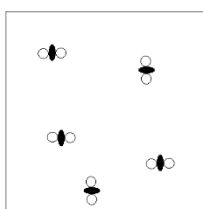
_____ C

4. Using phases and the simplest stoichiometric coefficients, write the chemical reaction.

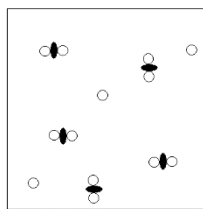
States of Matter, including intermolecular forces



A



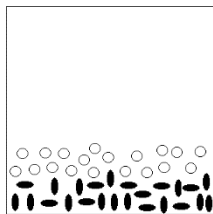
B



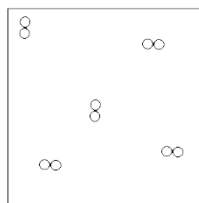
C



D



E



F

Refer to boxes A-F for questions 1-3.

1. Classify each of the above boxes as appropriate:

heterogeneous

homogeneous

mixture

mixture

compound

element

2. For the mixtures in the examples above, are they mixture of compounds, elements or compounds and elements?

3. Classify each of the above boxes as appropriate:

Solid

Liquid

Gas

4. For each of the substances below

a. classify as polar covalent, nonpolar covalent, ionic or metallic

b. determine the strongest intermolecular force present in a pure sample of the substance

MnSO₄

CH₃NH₂

K

PCl₅

SCl₂

O₂

LiF

5. Rank the substances in question 4 from highest melting point to lowest melting point.

6. Circle one of the hydrogen bonds in the collection of molecules below.

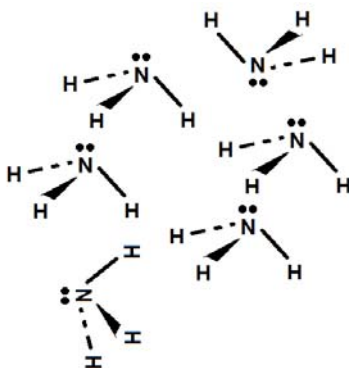


Figure 6

Periodicity

- Which of the following explains the trend in atomic size as you go across (left to right) on the periodic table?
 - size increases because there are more electrons
 - size decreases because there are more protons
 - size increases because a shell is added
 - size decreases because of increased shielding of the outer electrons
 - there is no change in size as you go across the periodic table.
- A negative value of electron affinity indicates that
 - an atom absorbs energy along with an electron
 - an atom releases energy along with an electron
 - an atom absorbs energy when it releases an electron
 - the atom releases energy when it adds an electron
 - there are no negative values of electron affinity
- Metallic character increases as you go
 - down and further right on the periodic table
 - down and further left on the periodic table
 - up and further right on the periodic table
 - up and further left on the periodic table

CHEM 1212 Example Questions

The exam is about equally distributed between CHEM 1211 topics and CHEM 1212 topics. The actual exam will be multiple choice. The below questions are guaranteed not to be on the exam.

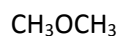
States of Matter/Solutions/IMFs

- Consider ethanol, $\text{CH}_3\text{CH}_2\text{OH}$, and dimethyl ether, CH_3OCH_3 , to answer the following questions.
 - What type(s) of IMFs does ethanol exhibit?
 - What type(s) of IMFs does dimethyl ether exhibit?

- c. Which of the two molecules has the stronger IMFs?
- d. Which of the two molecules has the greatest surface tension?
- e. If ethanol and dimethyl ether are held at the same temperature, will ethanol evaporate at the same rate, slower or faster than dimethyl ether? Explain your answer.

For each substance below:

- a) if it is ionic, write the formulas of the component ions
 b) if it is covalent, draw the Lewis structure



_____ 2. Which of the substances above, if any, have hydrogen bonding?

_____ 3. Which of the substances above has the highest vapor pressure?

4. In which of the following would dispersion forces be the **only significant** factors in determining boiling point?

- I. Ar II. Li_2SO_4 III. CF_4 IV. Br_2 V. NH_3
 a) I, II, and III b) II, IV, and V c) I, III, and IV d) I, IV and V e) II and V

5. Choose the substance with the highest boiling point.

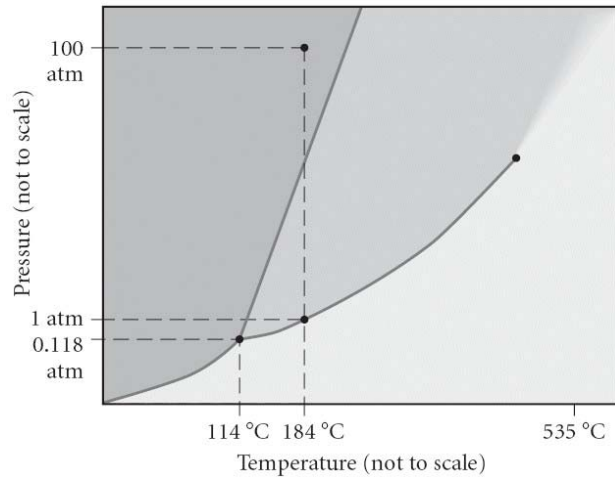
- a) CH_4 b) KI c) CS_2 d) HF e) I_2

6. Which of the following compounds will be most soluble in pentane (C_5H_{12})?

- a) pentanol ($\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$)
 b) benzene (C_6H_6)
 c) acetic acid ($\text{CH}_3\text{CO}_2\text{H}$)
 e) ethyl methyl ketone ($\text{CH}_3\text{CH}_2\text{COCH}_3$)
 e) None of these compounds should be soluble in pentane.

7. Place the following substances in order of **increasing** vapor pressure at a given temperature.

- NF_3 NH_3 BCl_3
- a) $\text{NH}_3 < \text{NF}_3 < \text{BCl}_3$ b) $\text{NF}_3 < \text{NH}_3 < \text{BCl}_3$ c) $\text{BCl}_3 < \text{NF}_3 < \text{NH}_3$
 d) $\text{NH}_3 < \text{BCl}_3 < \text{NF}_3$ e) $\text{BCl}_3 < \text{NH}_3 < \text{NF}_3$



8. Consider the phase diagram above. If the dashed line at 1 atm of pressure is followed from 100 to 500 °C, what phase changes will occur (in order of increasing temperature)?

- condensation, followed by vaporization
- sublimation, followed by deposition
- vaporization, followed by deposition
- melting, followed by vaporization
- No phase change will occur under the conditions specified.

9. An aqueous solution of copper (II) chloride is made using 72.5 g of copper (II) chloride diluted to a total solution volume of 1.50 L. Calculate the molarity, molality and mass percent of the solution (assume a density of 1.05 g/mL for the solution).

10. What is the van't Hoff factor for a dilute aqueous solution of $\text{Ca}(\text{NO}_3)_2$?

- 1
- 2
- 3
- 4
- 5

11. Which of these aqueous solutions would be expected to have the highest boiling point?

- 0.100 *m* CaCl_2
- 0.200 *m* NaOH
- 0.050 *m* K_2SO_4
- 0.050 *m* $\text{Al}_2(\text{SO}_4)_3$
- 0.200 *m* CH_3OH

12. Which aqueous solution would have the lowest vapor pressure at 25 °C? (no calculation is required)

- 1 *m* NaCl
- 1 *m* Na_3PO_4
- 1 *m* sucrose, $\text{C}_{12}\text{H}_{22}\text{O}_{11}$
- 1 *m* MgCl_2
- 1 *m* glucose, $\text{C}_6\text{H}_{12}\text{O}_6$

13. Classify the following as electrolytes or non-electrolytes.

a) CH_3OH _____

b) $\text{AgC}_2\text{H}_3\text{O}_2$ _____

c) K_2SO_3 _____

Energetics

1. If a 50.0 g piece of an unknown metal at 100.0°C is added to 50.0 g of water at 25.0 °C and the final temperature is measured to be 28.5 °C, what is the specific heat of the unknown metal?

2. Which of the following substances (with specific heat capacity provided) would show the greatest temperature change upon absorbing 100.0 J of energy?

a) 10.0 g Ag, $C_{Ag} = 0.235 \text{ J/g}^\circ\text{C}$

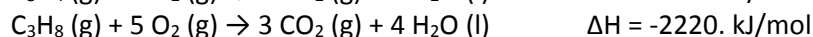
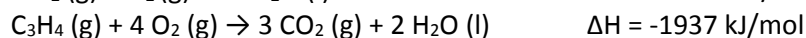
b) 10.0 g H_2O , $C_{H_2O} = 4.18 \text{ J/g}^\circ\text{C}$

c) 10.0 g ethanol, $C_{ethanol} = 2.42 \text{ J/g}^\circ\text{C}$

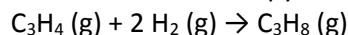
d) 10.0 g Fe, $C_{Fe} = 0.449 \text{ J/g}^\circ\text{C}$

e) 10.0 g Au, $C_{Au} = 0.128 \text{ J/g}^\circ\text{C}$

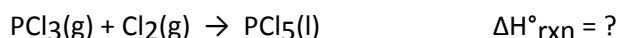
3. Given that,



Determine the enthalpy of the reaction below:

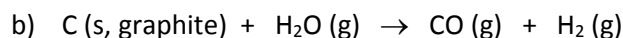
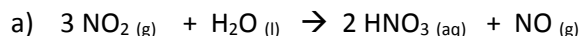


4. Use the bond energies provided to estimate ΔH°_{rxn} for the reaction below.

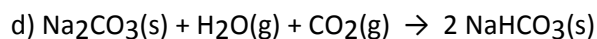
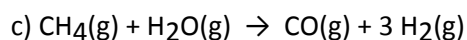
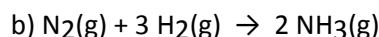
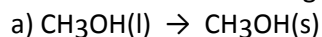


<u>Bond</u>	<u>Bond Energy (kJ/mol)</u>
Cl-Cl	243
P-Cl	331

5. Using tabulated standard enthalpies of formation (see the appendix in your textbook or online resource), calculate ΔH° for the following reactions:

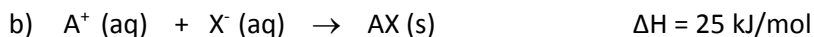


6. Which of the following processes have a $\Delta S > 0$?



e) All of the above processes have a $\Delta S > 0$.

7. Under what conditions would the following reactions be spontaneous?

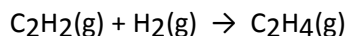


8. Place the following in order of decreasing molar entropy at 298 K.

HCl N₂H₄ Ar

- a) Ar > N₂H₄ > HCl b) Ar > HCl > N₂H₄ c) N₂H₄ > Ar > HCl
d) N₂H₄ > HCl > Ar e) HCl > N₂H₄ > Ar

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



$S^\circ(\text{J/mol}\cdot\text{K})$ 200.9 130.7 219.3

- A) +112.3 J/K B) +550.9 J/K C) -112.3 J/K D) +337.1 J/K E) -550.9 J/K

10. Estimate $\Delta G^\circ_{\text{rxn}}$ for the following reaction at 387 K.



- A) +243 kJ B) -72.9 kJ C) +84.9 kJ D) -92.5 kJ E) -188 kJ

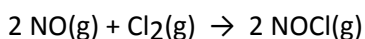
11. Use Hess's law to calculate $\Delta G^\circ_{\text{rxn}}$ using the following information.



- A) -60.0 kJ B) +651.6 kJ C) -265.8 kJ D) +137.2 kJ E) +523.0 kJ

Dynamics

1. Given the following balanced equation, determine the rate of reaction with respect to [NOCl]. If the rate of Cl₂ loss is $4.84 \times 10^{-2} \text{ M/s}$, what is the rate of formation of NOCl?



- a) $4.84 \times 10^{-2} \text{ M/s}$ b) $2.42 \times 10^{-2} \text{ M/s}$ c) $1.45 \times 10^{-1} \text{ M/s}$ d) $9.68 \times 10^{-2} \text{ M/s}$
e) $1.61 \times 10^{-2} \text{ M/s}$

2. The following kinetic data were obtained for the reaction

$$\text{NO}_2(\text{g}) + \text{O}_3(\text{g}) \rightleftharpoons \text{NO}_3(\text{g}) + \text{O}_2(\text{g})$$

Experiment	$[\text{NO}_2], \text{M}$	$[\text{O}_3], \text{M}$	initial rate (M/s)
1	0.21×10^{-3}	0.70×10^{-3}	6.3×10^{-3}
2	0.21×10^{-3}	1.39×10^{-3}	12.5×10^{-3}
3	0.38×10^{-3}	0.70×10^{-3}	11.4×10^{-3}
4	0.66×10^{-3}	0.18×10^{-3}	?

a. Write the rate law for this reaction (show your work).

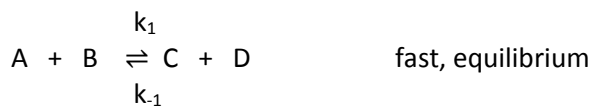
b. What is the order of the reaction (overall)?

c. Determine the value of the rate constant (with the correct units).

d. Predict the rate of the reaction in experiment 4 based on the determined rate law.

3. The first-order decomposition of N_2O at 1000 K has a rate constant of 0.76 s^{-1} . If the initial concentration of N_2O is 10.9 M, what is the concentration of N_2O after 9.6 s?

4. Using the following elementary steps, answer the questions below.



a) What is the overall or bulk reaction?

b) List any intermediates in the reaction mechanism (if any).

c) List any catalysts in the reaction mechanism (if any).

d) Write the rate law for the reaction (remember the rate law cannot contain reaction intermediates).

Equilibrium

1. Which of the following statements is FALSE?

- a) When $K \gg 1$, the forward reaction is favored and essentially goes to completion.
- b) When $K \ll 1$, the reverse reaction is favored and the forward reaction does not proceed to a great extent.
- c) When $K \approx 1$, neither the forward or reverse reaction is strongly favored, and about the same amount of reactants and products exist at equilibrium.
- d) $K \gg 1$ implies that the reaction is very fast at producing products.
- e) None of the above.

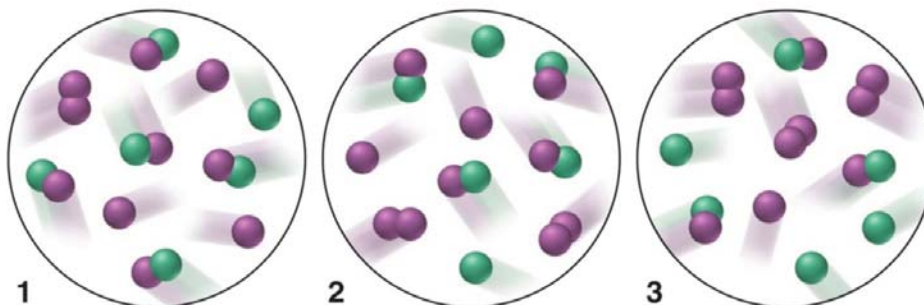
2. For the reaction $\text{N}_2(\text{g}) + 3 \text{H}_2(\text{g}) \rightleftharpoons 2 \text{NH}_3(\text{g})$, $K = 1.8 \times 10^4$ at a particular temperature. If the equilibrium concentrations of N_2 and NH_3 are 0.015 M and 2.00 M, what is the equilibrium concentration of H_2 ?

3. Which of the following statements are TRUE?

- a) Dynamic equilibrium occurs when the rate of the forward reaction equals the rate of the reverse reaction.
- b) The equilibrium constant for the forward reaction is equal to the equilibrium constant for the reverse reaction.
- c) A reaction quotient (Q) larger than the equilibrium constant (K) means that the reaction will favor the production of more products.
- d) Dynamic equilibrium indicates that the amount of reactants and products are equal.
- e) All of the above are true.

4. The reaction $\text{NiO}(\text{s}) + \text{CO}(\text{g}) \rightleftharpoons \text{Ni}(\text{s}) + \text{CO}_2(\text{g})$ has $K_c = 4.00 \times 10^1$. If a mixture of solid nickel (II) oxide and 0.350 M CO come to equilibrium, what will be the equilibrium concentration of carbon dioxide?

5. Consider the reaction and scenario below and answer the questions that follow (note: you MUST be able to see the colors to solve this problem):



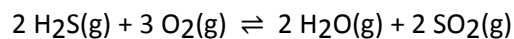
a. If $K = 2$ at the temperature of the reaction, which scene represents the mixture at equilibrium?

b. Will the reaction mixtures in the other two scenes proceed toward reactant or toward products to reach equilibrium?

c. For the mixture at equilibrium, how will a rise in temperature affect $[Y_2]$ and K ?

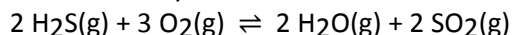
d. How will a decrease in pressure influence the mixture at equilibrium?

6. Consider the following reaction at equilibrium. What effect will adding more H_2S have on the system?



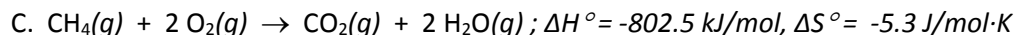
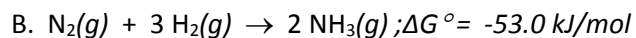
- a) reaction shifts left b) No change c) The equilibrium constant will decrease.
d) The equilibrium constant will increase. e) reaction shifts right

7. Consider the following reaction at equilibrium. What effect will increasing the volume of the reaction mixture have on the system?



- a) increases $[SO_2]$ b) No effect c) decreases $[SO_2]$
d) The equilibrium constant will decrease. e) The equilibrium constant will increase.

8. For the reactions below, calculate the equilibrium constant using the information given.



9. Which of the following is not true for ΔG_{rxn} ?

- a) If $\Delta G^\circ_{rxn} > 0$, the reaction is spontaneous in the forward direction.
b) If $Q = 1$, then $\Delta G_{rxn} = \Delta G^\circ_{rxn}$.
c) If $\Delta G^\circ_{rxn} = 0$, the reaction is spontaneous in the reverse direction.
d) If $\Delta G^\circ_{rxn} > 0$, the reaction is spontaneous in the reverse direction.
e) Under equilibrium conditions, $\Delta G_{rxn} = 0$.

10. Calculate the pH of 0.10 M solutions of the following substances.

- a. NaOH
b. NH_3
c. $HC_2H_3O_2$

- d. $\text{Ba}(\text{OH})_2$
- e. LiF

11. Which of the following solutions is a good buffer system?

- A) A solution that is 0.10 M NaCl and 0.10 M HCl
- B) A solution that is 0.10 M HCN and 0.10 M LiCN
- C) A solution that is 0.10 M NaOH and 0.10 M HNO_3
- D) A solution that is 0.10 M HNO_3 and 0.10 M KNO_3
- E) A solution that is 0.10 M HCN and 0.10 M NaCl

Electrochemistry/REDOX

1. Balance the following redox reactions using the half-reaction method and determine the number of electrons transferred in each reaction. Also identify the oxidation and reduction half-reactions.

- a) $\text{Pb}(\text{s}) + \text{Cl}_2(\text{g}) \rightarrow \text{PbCl}_2(\text{s})$
- b) $\text{K}(\text{s}) + \text{Al}^{3+}(\text{aq}) \rightarrow \text{K}^+(\text{aq}) + \text{Al}(\text{s})$
- c) $\text{Ag}|\text{Ag}^+||\text{Cr}^{3+}|\text{Cr}$

2. Consider the voltaic cell below and answer the questions that follow:

- a) What is the overall reaction?
- b) What is the anode? The cathode?
- c) What species is oxidized? reduced?
- d) What should the voltmeter read?
- e) What is the ΔG° for the reaction if all species in aqueous solution are at a concentration of 1.0 M?
- f) Write the shorthand notation for the standard cell.
- g) What is the ΔG for the reaction if the concentration of Ag^+ is 0.25 M and the concentration of Ni^{2+} is 0.75 M?

