CHEMISTRY 110 Final EXAM
Dec 17, 2012
FORM A

1. Given the following reaction which of the following statements is true?

   \[ \text{Fe(s)} + \text{CuCl}_2(\text{aq}) \rightarrow \text{Cu(s)} + \text{FeCl}_2(\text{aq}) \]

   A. Iron is oxidized and copper is reduced.
   B. Iron is reduced and copper is oxidized.
   C. Copper is reduced and chlorine is oxidized.
   D. Chlorine is the oxidizing agent.
   E. Iron is oxidized and chlorine is reduced.

2. Consider the following two reactions:

   \[ \frac{2\text{A}}{\text{K}_c1} \rightleftharpoons \frac{4\text{B}}{} \]

   \[ \text{A} \rightleftharpoons \frac{\text{K}_c2}{2\text{B}} \]

   What will be the value of \( \frac{\text{K}_{c1}}{\text{K}_{c2}} \)?

   A. \( \text{K}_{c1} \)
   B. \( \text{K}_{c2} \)
   C. \( \frac{1}{\text{K}_{c1}} \)
   D. \( \frac{1}{\text{K}_{c2}} \)
   E. impossible to determine

3. A hot air balloon holds a volume of \( 2.83 \times 10^6 \) L of gas. If the gas temperature inside the balloon is 120 °C at 1.0 atm pressure, what mass of helium gas will be needed to inflate the balloon to its full capacity?

   A. 87.7 kg
   B. 287 kg
   C. 301 kg
   D. 351 kg
   E. 553 kg

4. What is the frequency of electromagnetic radiation with wavelength 532 nm.

   A. \( 5.64 \times 10^{14} \text{s}^{-1} \)
   B. \( 6.48 \times 10^{15} \text{s}^{-1} \)
   C. \( 4.18 \times 10^{18} \text{s}^{-1} \)
   D. \( 6.23 \times 10^{14} \text{s}^{-1} \)
   E. \( 3.75 \times 10^{15} \text{s}^{-1} \)
5. What is the maximum number of electrons in aluminum (Al) that can have a spin quantum number with a value of \( m_s = 1/2 \)? Assume aluminum is in its ground state.

A. 6  
B. 7  
C. 9  
D. 11  
E. 13  

6. Which of the following photons with the given wavelengths contain(s) energy large enough to break a C–Br bond? The bond enthalpy is 276 kJ/mol.

- i. One 330 nm photon
- ii. One 430 nm photon
- iii. One 530 nm photon
- iv. One 4.30 \( \times 10^5 \) nm photon
- v. One 5.30 \( \times 10^5 \) nm photon

A. i only  
B. i and ii only  
C. i, ii, and iii only  
D. i, ii, iii, and iv only  
E. all five photons  

7. Which of the following graphs shows an equilibrium being established between two species, A and B?

A.  
B.  
C.  
D.  
E.  

8. What is the approximate enthalpy change during the following reaction based on the given bond enthalpies?

\[
2 \text{HCl(g)} + \text{F}_2(g) \rightarrow 2 \text{HF(g)} + \text{Cl}_2(g) \quad \Delta H^\circ = ?
\]

\[
\begin{array}{|c|c|}
\hline
\text{Bond} & \text{Bond Dissociation Energy} \\
\hline
\text{H–Cl} & 431 \text{ kJ/mol} \\
\text{F–F} & 155 \text{ kJ/mol} \\
\text{H–F} & 567 \text{ kJ/mol} \\
\text{Cl–Cl} & 242 \text{ kJ/mol} \\
\hline
\end{array}
\]

A. –359 kJ  
B. +359 kJ  
C. +1395 kJ  
D. –2393 kJ  
E. +2393 kJ
9. What are the approximate bond angles indicated on the molecule below?

![Molecule Diagram]

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>120°</td>
<td>180°</td>
</tr>
<tr>
<td>B.</td>
<td>90°</td>
<td>109.5°</td>
</tr>
<tr>
<td>C.</td>
<td>109.5°</td>
<td>180°</td>
</tr>
<tr>
<td>D.</td>
<td>120°</td>
<td>120°</td>
</tr>
<tr>
<td>E.</td>
<td>109.5°</td>
<td>120°</td>
</tr>
</tbody>
</table>

10. What is the hybridization of the O and the N in the molecule below?

![Molecule Diagram]

<table>
<thead>
<tr>
<th></th>
<th>O</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>sp</td>
<td>sp</td>
</tr>
<tr>
<td>B.</td>
<td>sp²</td>
<td>sp²</td>
</tr>
<tr>
<td>C.</td>
<td>sp³</td>
<td>sp²</td>
</tr>
<tr>
<td>D.</td>
<td>sp³</td>
<td>sp³</td>
</tr>
<tr>
<td>E.</td>
<td>sp²</td>
<td>sp³</td>
</tr>
</tbody>
</table>

11. What is the **electron domain geometry** about the iodine in IF$_2^-$?

A. linear
B. trigonal planar
C. tetrahedral
D. octahedral
E. trigonal bipyramidal

12. A substance transitions, by increasing the pressure, from point A (initial state) to point B (final state) on its phase diagram. What is the phase for the substance in its initial and final states and what change(s) in phase does the substance undergo?

![Phase Diagram]

<table>
<thead>
<tr>
<th>Initial state</th>
<th>Phase changes</th>
<th>Final state</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>solid</td>
<td>solid → liquid</td>
</tr>
<tr>
<td>B.</td>
<td>solid</td>
<td>solid → liquid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>liquid → gas</td>
</tr>
<tr>
<td>C.</td>
<td>liquid</td>
<td>liquid → gas</td>
</tr>
<tr>
<td>D.</td>
<td>gas</td>
<td>gas → solid</td>
</tr>
<tr>
<td>E.</td>
<td>gas</td>
<td>gas → liquid</td>
</tr>
</tbody>
</table>
13. How many unpaired electrons are present in a ground state Ni\(^{2+}\) ion?
   A. 0
   B. 1
   C. 2
   D. 4
   E. 8

14. Arrange the ions in order of decreasing radius.
   Br\(^-\), Rb\(^+\), Ca\(^{2+}\), Sr\(^{2+}\)
   A. Br\(^-\) > Ca\(^{2+}\) > Rb\(^+\) > Sr\(^{2+}\)
   B. Br\(^-\) > Ca\(^{2+}\) > Sr\(^{2+}\) > Rb\(^+\)
   C. Sr\(^{2+}\) > Rb\(^+\) > Br\(^-\) > Ca\(^{2+}\)
   D. Sr\(^{2+}\) > Rb\(^+\) > Ca\(^{2+}\) > Br\(^-\)
   E. Br\(^-\) > Rb\(^+\) > Sr\(^{2+}\) > Ca\(^{2+}\)

15. Which of the following samples contains the smallest number of total atoms?
   A. 0.5 mole of ethane (C\(_2\)H\(_6\))
   B. 6.02 \times 10^{23} molecules of methane (CH\(_4\))
   C. 36 grams of water
   D. a 22.41 L container at STP of CO\(_2\) (g)
   E. 2.4 \times 10^{24} atoms of xenon (Xe)

16. The C atoms are shown explicitly for one C–C bond in each of the hydrocarbons given below. Put those C–C bonds in order of increasing bond length.

   1. \(\text{C} - \text{C}\)
   2. \(\text{C} - \text{C}\)
   3. \(\text{C} - \text{C}\)
   4. \(\text{C} = \text{C}\)

   A. 4 < 3 < 2 < 1
   B. 1 = 3 = 4 < 2
   C. 4 = 3 = 2 < 1
   D. 2 < 4 < 1 = 3
   E. 2 = 4 < 3 = 1

17. Which of the following has no net dipole moment?
   A. N\(_2\)O
   B. NF\(_3\)
   C. H\(_2\)Se
   D. SO\(_3\)
   E. CH\(_3\)Cl

Go on to the next page
18. Which of the following molecules is a structural isomer of 1-hexene (shown below)?

A. 1 and 2  
B. 1 and 3  
C. 3 and 4  
D. 1, 2, and 3  
E. 1 and 4

19. Which of these ionic solids would have the largest lattice energy?

A. CaO  
B. NaF  
C. SrO  
D. CsI  
E. BaS

20. Which of the following pure substances will have H-bonding as one of its intermolecular forces?

A. only 3  
B. only 4  
C. 3 and 4  
D. 2, 3 and 4  
E. all four compounds

21. Which of the following statements about solubility is incorrect?

A. The solubility of an inert gas typically increases when the temperature of the solution is decreased.  
B. The solubility of an inert gas typically increases when the pressure in the container is increased by adding another inert gas.  
C. The solubility of a gas increases when the partial pressure of that gas is increased.  
D. The solubility of a solid is typically not affected by pressure change.  
E. Intermolecular forces between solute and solvent molecules are a factor affecting solubility.
22. Three 5 L flasks contain 4.0 g of gas at 273 K. If flask A contains H₂, flask B contains CH₄, and flask C contains SO₂, which flask has highest pressure and which one has molecules moving at the highest average molecular speed?

<table>
<thead>
<tr>
<th>Highest Pressure</th>
<th>Highest Average Molecular Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Flask A</td>
<td>Flask A</td>
</tr>
<tr>
<td>B. Flask B</td>
<td>Flask A</td>
</tr>
<tr>
<td>C. Flask C</td>
<td>Flask B</td>
</tr>
<tr>
<td>D. Flask A</td>
<td>Flask C</td>
</tr>
<tr>
<td>E. All have the same P</td>
<td>Flask A</td>
</tr>
</tbody>
</table>

23. A surgical iodine preparation solution has a density of 0.860 g/mL and contains approximately 0.7 wt% iodine, 74 wt% isopropyl alcohol, 15 wt% water, and the balance ethyl alcohol. What is the molarity of iodine?

A. 0.70 M  
B. 0.81 M  
C. 0.10 M  
D. 0.07 M  
E. 0.02 M  

24. Which properties follow the correct trends with increasing intermolecular forces?

<table>
<thead>
<tr>
<th></th>
<th>Viscosity</th>
<th>Boiling Temp</th>
<th>Vapor Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>decrease</td>
<td>increase</td>
<td>increase</td>
</tr>
<tr>
<td>B.</td>
<td>increase</td>
<td>increase</td>
<td>increase</td>
</tr>
<tr>
<td>C.</td>
<td>decrease</td>
<td>decrease</td>
<td>increase</td>
</tr>
<tr>
<td>D.</td>
<td>increase</td>
<td>decrease</td>
<td>decrease</td>
</tr>
<tr>
<td>E.</td>
<td>increase</td>
<td>increase</td>
<td>decrease</td>
</tr>
</tbody>
</table>

25. 100 mL of a 0.10 M NaCl is mixed with a 100 mL of 0.20 M MgCl₂. What is the final concentration of chloride anions?

A. 0.10 M  
B. 0.35 M  
C. 0.05 M  
D. 0.15 M  
E. 0.25 M
26. 160 g Fe₂O₃ (s) and 84.0 g CO (g) are combined and allowed to react as follows:

\[ \text{Fe}_2\text{O}_3 (s) + 3 \text{ CO (g)} \rightarrow 2 \text{ Fe (s)} + 3 \text{ CO}_2 (g) \]

When the reaction comes to completion, 93.5 g of Fe (s) has formed. What is the percent yield of the reaction?

A. 26.5%  
B. 43.1%  
C. 67.2%  
D. 83.7%  
E. 100%

27. Calculate the standard enthalpy of formation of one mole of gaseous ethane (C₂H₆) using the following information.

\[
\begin{align*}
\text{C(graphite)} + \text{O}_2(g) &\rightarrow \text{CO}_2(g) & \Delta H_{\text{rxn}}^\circ &= -393.5 \text{ kJ} \\
2 \text{ H}_2(g) + \text{O}_2(g) &\rightarrow 2 \text{ H}_2\text{O}(l) & \Delta H_{\text{rxn}}^\circ &= -571.6 \text{ kJ} \\
2 \text{ C}_2\text{H}_4(g) + 7 \text{ O}_2(g) &\rightarrow 4 \text{ CO}_2(g) + 6 \text{ H}_2\text{O}(l) & \Delta H_{\text{rxn}}^\circ &= -3119.6 \text{ kJ}
\end{align*}
\]

A. -84.6 kJ  
B. +210.1 kJ  
C. -346.0 kJ  
D. -35.3 kJ  
E. +321.2 kJ

28. Two flasks are shown below. Each contains the labeled gasses at STP. The flasks are then opened to each other and the nitrogen and oxygen are allowed to react to form NO. If the system is then allowed to return to 0 °C, what is the final pressure of the system? (Assume the connecting volume is negligible.)

A. 0.5 atm  
B. 1.0 atm  
C. 1.5 atm  
D. 2.0 atm  
E. 3.0 atm

29. For which of the following reactions (at 25°C and 1 atm) has a heat of reaction \( \Delta H_{\text{rxn}} \) that is equal to \( \Delta H_f^\circ \) of the product?

A. \( \text{H}_2(g) + \text{F}_2(g) \rightarrow 2\text{HF(g)} \)  
B. \( \text{C}_2\text{H}_4(g) + \text{H}_2\text{O}(g) \rightarrow \text{C}_2\text{H}_5\text{OH}(l) \)  
C. \( \text{Pb}(s) + \text{Cl}_2(g) \rightarrow \text{PbCl}_2(s) \)  
D. \( \text{S}(s) + \text{O}_3(g) \rightarrow \text{SO}_4(g) \)  
E. \( \text{HCl (g)} + \frac{1}{2} \text{ Br}_2(g) \rightarrow \text{HBr(g)} + \frac{1}{2} \text{ Cl}_2(g) \)
30. The gases in flask containing only NOBr (g), NO (g), and Br₂ (g) are at equilibrium.

\[ 2\text{NOBr} (g) \rightleftharpoons 2\text{NO} (g) + \text{Br}_2 (g) \]

At 0°C the equilibrium concentrations are: [NOBr] = 1.12 \times 10^{-3} \text{ M}, [NO] = 3.09 \times 10^{-3} \text{ M} and [Br₂] = 1.84 \times 10^{-3} \text{ M}.

What is the value of \( K_p \) for this reaction?

A. 0.314
B. 5.08
C. 3.18
D. 1.12
E. 6.05

31. The table below describes the equilibrium concentrations of A and B at different conditions for the reaction \( A \rightleftharpoons 2B \).

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Pressure</th>
<th>[A]_{eq}</th>
<th>[B]_{eq}</th>
</tr>
</thead>
<tbody>
<tr>
<td>273 K</td>
<td>1 atm</td>
<td>0.12 M</td>
<td>0.06 M</td>
</tr>
<tr>
<td>298 K</td>
<td>1 atm</td>
<td>0.13 M</td>
<td>0.04 M</td>
</tr>
<tr>
<td>273 K</td>
<td>2 atm</td>
<td>0.12 M</td>
<td>0.06 M</td>
</tr>
</tbody>
</table>

Which of the following statements are true?

i) A and B are both gases
ii) The reaction is exothermic
iii) The reaction is endothermic

A. i
B. ii
C. iii
D. i and ii
E. i and iii

32. If \( K_c = 3 \) for the reaction \( X (g) + 2 \text{Y} (g) \rightleftharpoons \text{Z} (g) \) at a certain temperature, then for each of the mixtures of X, Y, and Z shown below, in what direction must the reaction proceed to achieve equilibrium? The number of spheres is equal to the concentration.

![Diagram](https://via.placeholder.com/150)

**System I**
- reaction shifts to left

**System II**
- reaction shifts to right

A. reaction shifts to left
B. reaction shifts to right
C. reaction is at equilibrium
D. reaction shifts to left
E. reaction shifts to right
33. Which one of the following aqueous solutions has a freezing point of \(-2.60^\circ\text{C}\)? (\(K_f\) for water is 1.86°C/m)
   A. 1.30 m Na\(_2\)CO\(_3\) (aq)
   B. 0.47 m NaBr (aq)
   C. 0.20 m K\(_2\)SO\(_4\) (aq)
   D. 0.35 m AlCl\(_3\) (aq)
   E. 0.24 m CH\(_3\)OH (aq)

34. Lithium forms compounds which are used in dry cells and storage batteries and in high-temperature lubricants. It has two naturally occurring isotopes, \(^6\text{Li}\) (isotopic mass = 6.015121 amu) and \(^7\text{Li}\) (isotopic mass = 7.016003 amu). Lithium has an atomic mass of 6.9409 amu. What is the percent abundance of lithium-6?
   A. 92.50%
   B. 86.66%
   C. 46.16%
   D. 7.503%
   E. 6.080%

35. A 5.0 gram sample of an unknown organic is completely combusted to yield 9.77 grams of CO\(_2\) and 4.99 grams of H\(_2\)O. What is the empirical formula of the compound?
   A. C\(_2\)H\(_5\)
   B. C\(_2\)H\(_5\)O
   C. C\(_2\)H\(_2\)O\(_2\)
   D. C\(_3\)H\(_6\)O
   E. C\(_3\)H\(_6\)O\(_2\)

36. What is the value of \(n_i\) for an electron that emits a photon of wavelength 121.7 nm when it returns to the ground state in the H atom?
   A. \(n_i = 6\)
   B. \(n_i = 5\)
   C. \(n_i = 4\)
   D. \(n_i = 3\)
   E. \(n_i = 2\)
37. A quantity of 200 mL of 0.862 M HCl (aq) is mixed with 200 mL of 0.431 M Ba(OH)$_2$ (aq) in a constant-pressure calorimeter of negligible heat capacity. The initial temperature of HCl and Ba(OH)$_2$ solutions is the same at 20.5 °C. The heat of neutralization for the process below is –56.2 kJ/mol.

$$\text{H}^+ \text{(aq)} + \text{OH}^- \text{(aq)} \rightarrow \text{H}_2\text{O}(l)$$

What is the final temperature of the mixed solution? Assume the density of the solution is the same as that of water (1.00 g/mL), and the specific heat of the solution is the same as that for pure water, 4.184 J/(g°C).

A. 54.1 °C  
B. 26.3 °C  
C. 14.7 °C  
D. 13.1 °C  
E. 8.9 °C

38. Which one of the following will have a resonance structure as the best Lewis structure?

A. SO$_3$  
B. NF$_3$  
C. I$_3^-$  
D. SCO (C = central atom)  
E. C$_2$H$_4$

39. If 50 mL of 0.1 M nitric acid is mixed with 50 mL of 0.1 M barium hydroxide, what is the concentration of OH$^-$ ions in the final mixture?

A. There are no OH$^-$ ions in solution because the solution is completely neutralized.  
B. 0.0050 M  
C. 0.010 M  
D. 0.050 M  
E. 0.10 M

40. The equilibrium constant K$_c$ for the reaction below is 0.534 at 700 °C.

$$\text{H}_2(g) + \text{CO}_2(g) \rightleftharpoons \text{H}_2\text{O}(g) + \text{CO}(g)$$

Initially 0.030 mole of CO (g) and 0.030 mole of H$_2$O(g) are injected into a 1.0-L flask. What is the number of moles of CO$_2$ (g) that are present at equilibrium?

A. 0.0514 mol  
B. 0.0035 mol  
C. 0.0173 mol  
D. 0.0125 mol  
E. 0.0108 mol
FORM A

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