2007 Concept Final

1. Which of the following are strong electrolytes. (There is more than one correct answer.)
   
   a) HF  
   b) HCl  
   c) NaCl  
   d) CH₃OH  
   e) NaOH  
   f) K₂SO₄  
   g) NH₃  
   h) H₂CO₃  
   i) H₂O  
   j) ZnCl₂  
   k) Fe(NO₃)₂  
   l) Ca(OH)₂  
   m) KI  
   n) H₃PO₄  
   o) CH₃COOH (acetic acid)  
   p) C₆H₁₂O₆ (glucose)

2. Consider the following reaction at equilibrium.

\[
2 \text{NH}_3(g) \rightleftharpoons \text{N}_2(g) + 3 \text{H}_2(g) \quad \Delta H^\circ = +92.4 \text{ kJ}
\]

Adding N₂(g) to the reaction vessel will

a) decrease the concentration of NH₃(g) at equilibrium.  
   b) decrease the concentration of H₂(g) at equilibrium.  
   c) increase the value of the equilibrium constant.  
   d) cause the reaction to shift to the right.  
   e) have no effect on the concentration of NH₃(g).

3. What is the heat of formation of ozone?

\[
3 \text{O}_2(g) \rightarrow 2 \text{O}_3(g) \quad \Delta H_{\text{rxn}} = 284.6 \text{ kJ}
\]

a) 142.3 kJ  
   b) 284.6 kJ  
   c) 569.2 kJ  
   d) 426.9 kJ  
   e) There is not enough information to determine the answer.

4. How many kJ of heat will evolve when 41 g of HBr is formed in this reaction?

\[
\text{H}_2(g) + \text{Br}_2(g) \rightarrow 2 \text{HBr(g)} \quad \Delta H = -72 \text{ kJ}
\]

a) 0.49 kJ  
   b) 36 kJ  
   c) 71 kJ  
   d) 18 kJ
5. The following substances are fertilizers that contribute nitrogen to the soil: urea [(NH$_2$)$_2$CO]; ammonium nitrate; ammonium sulfate. Arrange these fertilizers in order of decreasing nitrogen content on a mass percentage basis.

a) ammonium nitrate > urea > ammonium sulfate
b) ammonium nitrate > ammonium sulfate > urea
c) urea ≅ ammonium sulfate ≅ ammonium nitrate
d) urea > ammonium nitrate > ammonium sulfate
e) ammonium sulfate ≅ ammonium nitrate > urea

6. Rank these aqueous solutions in order of increasing freezing point.

0.08 m glucose  0.06 m LiBr  0.03 m Zn(NO$_3$)$_2$

a) LiBr < Zn(NO$_3$)$_2$ < glucose
b) Zn(NO$_3$)$_2$ < LiBr < glucose
c) glucose < LiBr < Zn(NO$_3$)$_2$
d) Zn(NO$_3$)$_2$ < glucose < LiBr
e) They all have the same freezing points.

7. What is the molecular geometry of ICl$_2^-$?

a) trigonal planar
b) linear
c) bent
d) trigonal bipyramid
e) tetrahedral

8. Which one of the following descriptions of SF$_4$ and XeF$_4$ is correct?

<table>
<thead>
<tr>
<th>electron pair geometry</th>
<th>molecular geometry</th>
<th>polar?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. trigonal bipyramidal</td>
<td>seesaw</td>
<td>polar</td>
</tr>
<tr>
<td>2. tetrahedral</td>
<td>tetrahedral</td>
<td>nonpolar</td>
</tr>
<tr>
<td>3. octahedral</td>
<td>square planar</td>
<td>nonpolar</td>
</tr>
<tr>
<td>4. octahedral</td>
<td>square pyramidal</td>
<td>polar</td>
</tr>
</tbody>
</table>

a) SF$_4$ = 4 and XeF$_4$ = 2
b) SF$_4$ = 1 and XeF$_4$ = 4
c) SF$_4$ = 2 and XeF$_4$ = 2
d) SF$_4$ = 1 and XeF$_4$ = 3
e) SF$_4$ = 3 and XeF$_4$ = 1
9. A solute is dissolved in water. Which one of the following statements is false?

a) If the solute is a nonvolatile solid, the solubility of the solute will increase if T increases.

b) If the solute is a gas, the solubility of the solute will decrease if T increases.

c) If the solute is a nonvolatile solid, the solubility of the solute will decrease if P increases.

d) If the solute is a gas, the solubility of the solute will increase if P_g increases.

10. A nonvolatile solute is added to a liquid. Which one of the following statements is false?

a) The vapor pressure of the liquid decreases.

b) The freezing point of the liquid decreases.

c) The boiling point of the liquid increases.

d) The osmotic pressure of the solution increases.

e) The osmotic pressure of the solution decreases.

11. For the following reaction:

\[ \text{N}_2(\text{g}) + 3 \text{H}_2(\text{g}) \rightleftharpoons 2 \text{NH}_3(\text{g}) \quad \Delta H^\circ = -92.4 \text{ kJ} \]

Which of the following will increase the amount of NH_3(g) produced? (There may be more than one correct answer.)

a) removing some H_2(g)

b) raising the temperature

c) increasing the total pressure

d) decreasing the volume

e) adding a catalyst

12. Which one of the following molecules is a ketone?

a) b) c) d) e)
Use the following phase diagram to answer the next 3 questions?

13. Starting at $T = 0 \text{ K}$ and $P = 1 \text{ atm}$, what phases are present as one increases $T$ to 500 K while holding $P$ constant?
   
a) solid, solid-liquid coexistence, liquid, liquid-gas coexistence, gas
   b) gas, gas-liquid coexistence, liquid, liquid-solid coexistence, solid
   c) gas, gas-solid coexistence, solid
   d) liquid, liquid-solid coexistence, solid
   e) solid, solid-gas coexistence, gas

14. The point labeled “E” corresponds to
   
a) the critical point
   b) the triple point
   c) the normal melting point
   d) the normal boiling point
   e) the freezing point

15. The point labeled “B” corresponds to
   
a) the critical point
   b) the triple point
   c) the normal melting point
   d) the normal boiling point
   e) supercritical point

16. Which of the following molecules has (have) H-bonding as a contribution to its intermolecular forces?
   
   1. CH$_3$F   2. PH$_3$   3. H$_2$S   4. NH$_3$
   
a) only 1
   b) only 4
   c) 1 and 4
   d) 1 and 3
   e) 1 and 2
17. Which one of the following has the strongest intermolecular forces?

<table>
<thead>
<tr>
<th>Compound</th>
<th>Molecular Formula</th>
<th>Boiling point</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) diethyl ether</td>
<td>C₄H₁₀O</td>
<td>34.6°C</td>
</tr>
<tr>
<td>b) ethanol</td>
<td>C₂H₆O</td>
<td>78.3°C</td>
</tr>
<tr>
<td>c) water</td>
<td>H₂O</td>
<td>100.0°C</td>
</tr>
<tr>
<td>d) methyl-ethyl ketone</td>
<td>C₄H₈O</td>
<td>79.0°C</td>
</tr>
<tr>
<td>e) methyl acetate</td>
<td>C₃H₆O₂</td>
<td>57.0°C</td>
</tr>
</tbody>
</table>

18. Using the same choices above in Q17, which of the molecules has the highest vapor pressure at 20°C?

a) diethyl ether
b) ethyl alcohol
c) water
d) methyl-ethyl ketone
e) methyl acetate

19. The labeled C in 2-pentene has ______ hybrid orbitals.

\[
\begin{align*}
&\text{H} \quad \text{C} = \text{C} \quad \text{H} \\
&\quad \text{H} \quad \text{C} \quad \text{H} \\
&\text{H} \quad \text{C} \quad \text{CH₂CH₃}
\end{align*}
\]

a) \(\text{sp}_3\)
b) \(\text{sp}^2\)
c) \(\text{sp}^3\)
d) \(\text{sp}^4\)
e) \(\text{sp}^3\) d

20. Which one of the following molecules is most likely to be soluble in water?

a) methane (CH₄)
b) N₂
c) PF₅
d) CH₃OH
e) XeF₂
21. How many $\sigma$ and $\pi$ bonds are in caffeine?

![Caffeine structure]

a) 24 $\sigma$ and 2 $\pi$

b) 29 $\sigma$ and 0 $\pi$

c) 25 $\sigma$ and 4 $\pi$

d) 14 $\sigma$ and 2 $\pi$

e) 25 $\sigma$ and 3 $\pi$

22. There are different gases in three connected, but separate containers, under the conditions given below.

<table>
<thead>
<tr>
<th></th>
<th>N2</th>
<th>CO2</th>
<th>Ar</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V$</td>
<td>1.0 L</td>
<td>1.5 L</td>
<td>1.5 L</td>
</tr>
<tr>
<td>$P$</td>
<td>1.5 atm</td>
<td>1.5 atm</td>
<td>1.0 atm</td>
</tr>
<tr>
<td>$T$</td>
<td>298 K</td>
<td>298 K</td>
<td>298 K</td>
</tr>
</tbody>
</table>

The gases in the 3 containers are combined into a flask of total volume 4.0 L. Rank the three gases in order of increasing partial pressure.

a) $P_{N2} = P_{Ar} < P_{CO2}$

b) $P_{CO2} = P_{N2} < P_{Ar}$

c) $P_{N2} < P_{Ar} < P_{CO2}$

d) $P_{CO2} = P_{N2} = P_{Ar}$

e) There is not enough information to make this comparison.

23. When an Alka-Seltzer tablet dissolves in water, the following reaction between sodium bicarbonate and citric acid occurs:

$$3 \text{NaHCO}_3(\text{aq}) + \text{H}_3\text{C}_6\text{H}_5\text{O}_7(\text{aq}) \rightarrow 3 \text{CO}_2(\text{g}) + 3 \text{H}_2\text{O}({\text{l}}) + \text{Na}_3\text{C}_6\text{H}_5\text{O}_7(\text{aq})$$

If the tablet contains 84 g of NaHCO$_3$(s) and 192 g of H$_3$C$_6$H$_5$O$_7$(s), how many moles of CO$_2$(g) will form when the tablet is dissolved in water?

a) 0.33 moles

b) 0.5 moles

c) 1 mole

d) 2 moles

e) 3 moles
24. How many moles of butane \((C_4H_{10})\) must burn to produce 18 g of water?

a) 0.20 moles  
b) 0.25 moles  
c) 1.00 moles  
d) 2.00 moles  
e) 4.00 moles  
f) 5.00 moles

25. There are different gases in three connected, but separate containers, under the conditions given below.

<table>
<thead>
<tr>
<th></th>
<th>N(_2)</th>
<th>CO(_2)</th>
<th>Ar</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V)</td>
<td>1.0 L</td>
<td>2.0 L</td>
<td>0.5 L</td>
</tr>
<tr>
<td>(P)</td>
<td>1.0 atm</td>
<td>0.5 atm</td>
<td>1.5 atm</td>
</tr>
<tr>
<td>(T)</td>
<td>298 K</td>
<td>298 K</td>
<td>298 K</td>
</tr>
</tbody>
</table>

Which one of the following statements is false?

a) The Ar molecules undergo more frequent collisions than the molecules in the other two containers.

b) The CO\(_2\) molecules have the greatest average kinetic energy.

c) The mass of CO\(_2\) (g) is greater than the mass of Ar(g).

d) The rms speed of N\(_2\) is greater than the rms speed of Ar.

e) The rms speed of CO\(_2\) is lower than the rms speed of Ar.

26. A 0.25 M solution of magnesium nitrate is diluted to one half its original concentration. What is the total concentration of ions (magnesium ions AND nitrate ions) in the dilute solution?

a) 0.125 M  
b) 0.25 M  
c) 0.375 M  
d) 0.50 M  
e) 0.75 M

27. Which one of the following will have the longest NO bond?

a) NO\(^+\)  
b) NO\(^-\)  
c) NO\(_2\)^-  
d) NO\(_3\)^-  
e) The NO bond is the same length for c and d.
28. In which of the following reactions does $K_p = K_c$?

a) $\text{CH}_4(\text{g}) + 2 \text{H}_2\text{S}(\text{g}) \rightleftharpoons \text{CS}_2(\text{g}) + 4 \text{H}_2(\text{g})$

b) $3 \text{NO}(\text{g}) \rightleftharpoons \text{N}_2\text{O}(\text{g}) + \text{NO}_2(\text{g})$

c) $\text{Ni(II)}(\text{g}) \rightleftharpoons \text{Ni(s)} + 4 \text{CO(}\text{g})$

d) $\text{Fe}_2\text{O}_3(\text{s}) + 3 \text{H}_2(\text{g}) \rightleftharpoons 2 \text{Fe(s)} + 3 \text{H}_2\text{O(}\text{g})$

e) $2 \text{N}_2\text{O}_5(\text{g}) \rightleftharpoons 4 \text{NO}_2(\text{g}) + \text{O}_2(\text{g})$

29. A gas will behave most like an ideal gas _______. (There may be more than one correct answer.)

a) at STP.

b) at low temperatures and high pressures.

c) at high temperatures and low pressures.

d) when there are attractive intermolecular forces between the molecules.

e) when there is finite molecular volume.

30. Which one of the following transitions of an electron in a H atom will emit a photon with the smallest wavelength?

a) $n = 8$ to $n = 5$

b) $n = 6$ to $n = 3$

c) $n = 5$ to $n = 3$

d) $n = 2$ to $n = 1$

e) $n = 4$ to $n = 2$

31. The quantum numbers below are for 4 different electrons in the same atom. Rank them in order of increasing energy.

1. $n = 4, l = 0, m_l = 0, m_s = +\frac{1}{2}$

2. $n = 3, l = 2, m_l = 1, m_s = +\frac{1}{2}$

3. $n = 3, l = 2, m_l = -1, m_s = -\frac{1}{2}$

4. $n = 3, l = 1, m_l = 1, m_s = -\frac{1}{2}$

a) $4 < 3 < 2 < 1$

b) $4 < 3 = 2 < 1$

c) $4 = 3 = 2 < 1$

d) $4 < 1 < 3 < 2$

e) $4 < 1 < 3 = 2$
32. An electron has the quantum numbers \( n=3, l=2, m_l=-1, m_s=-\frac{1}{2} \). Which one of the following subshells is degenerate with this electron?

a) 2p  

b) 3s  

c) 3d  

d) 4s  

e) 4p

33. Which one of the following could not be an electron configuration for vanadium, \( V \)?

a) \( 1s^22s^22p^63s^23p^64s^23d^2 \)  

b) \( 1s^22s^22p^63s^23p^63d^5 \)  

c) \( 1s^22s^22p^63s^23p^64d^5 \)  

d) \( 1s^22s^22p^63s^23p^64s^24d^3 \)  

e) \( 1s^22s^22p^63s^23p^63d^35s^2 \)

34. How many unpaired electrons are there in the ground state electron configuration of \( \text{Co}^{2+} \)?

a) 1  

b) 2  

c) 3  

d) 4  

e) 5

35. Which quantum number governs the shape of an orbital?

a) principal quantum number  

b) azimuthal quantum number  

c) spin quantum number  

d) magnetic quantum number

36. Which quantum number(s) determine the energy of the orbitals in a many electron atom?

a) \( n \) only  

b) \( l \) only  

c) \( m_l \) only  

d) \( n \) and \( l \)  

e) \( l \) and \( m_l \)  

f) \( n, l \) and \( m_l \)
37. Which one of the following is the largest?
   a) Cl
   b) S^-
   c) Ar^+
   d) K^{+2}
   e) P^{2-}

38. Which one of these bonds can be broken by a photon with the shortest wavelength? The numbers in parentheses are the average bond dissociation energies.
   a) C—H (413 kJ/mol)
   b) C—Cl (328 kJ/mol)
   c) O—Cl (203 kJ/mol)
   d) C≡N (615 kJ/mol)
   e) C≡O (1072 kJ/mol)

39. If 100 mL of 1 M sulfuric acid is neutralized with 1M calcium hydroxide, how many mL of base must be added?
   a) 25 mL
   b) 50 mL
   c) 100 mL
   d) 150 mL
   e) 200 mL

40. Which of the following will have the lowest melting point?
   a) potassium chloride
   b) sodium chloride
   c) magnesium sulfide
   d) manganese(II) sulfide
   e) calcium sulfide

41. Which one of the following reactions has ΔH_{rxn} = ΔH^°_f?
   a) 2 SO_2(g) + O_2(g) → 2 SO_3(g)
   b) CaO(s) + CO_2(g) → CaCO_3(s)
   c) C_2H_4(g) + H_2(g) → C_2H_6(g)
   d) Br_2(l) + I_2(s) → 2 IBr(s)
   e) N_2(g) + 2 O_2(g) → N_2O_4(g)
42. Rank the bond angles labeled on the molecule below in order of increasing size.

\[ \text{H} \quad \text{N} \quad \text{C} \quad \text{O} \quad \text{H} \]

a) \( d < a < b < c \)  

b) \( b < a < d < c \)  

c) \( a = b = d < c \)  

d) \( a = d < b < c \)  

e) \( c < b < a < d \)  

43. What is the molecular formula of 1,3-di-methylcyclohexane (shown below)?

a) \( \text{C}_8\text{H}_{16} \)  

b) \( \text{C}_8\text{H}_{18} \)  

c) \( \text{C}_6\text{H}_{12} \)  

d) \( \text{C}_6\text{H}_{14} \)  

e) \( \text{C}_7\text{H}_{14} \)  

44. Which of the compounds shown below can have a geometrical isomer?

\[
\begin{align*}
1. & \quad \text{CH}_3 & \quad \text{CH}_3 & \quad \text{CH}_3 \\
2. & \quad \text{CH}_3 & \quad \text{CH}_3 & \quad \text{CH}_3 \\
3. & \quad \text{CH}_3 & \quad \text{CH}_3 & \quad \text{CH}_3
\end{align*}
\]

a) 1 only  

b) 2 only  

c) 3 only  

d) 1 and 2  

e) 2 and 3