-You will have 55 minutes to complete the exam. Follow the instructions carefully.
-The answers to the multiple choice questions must be filled out on the answer sheet provided using a #2 pencil.

**Write your name on this test AND on the answer sheet. You will lose 2 points for failing to put your name on each item.**

-Use significant figures correctly in longer problems.
-Show your calculations in problems.
-Use complete sentences in written responses.
-You may use a calculator, but no books, notes or other information may be used.
-A periodic table and table of atomic masses is available.
-Below are some useful relationships—not all will be used.

\[
T_K = T_C + 273.15 \\
T_F = T_C \left(\frac{9^\circ F}{5^\circ F}\right) + 32^\circ F \\
d = \frac{m}{V}
\]

1 amu = 1.66054 x 10^{-27} kg \hspace{1cm} N_A = 6.022 x 10^{23} \text{ mol}^{-1} \hspace{1cm} R = 8.314 \text{ J/(K·mol)}

\[
R = 8.314 \frac{\text{L·kPa}}{\text{mol·K}} = 0.0821 \frac{\text{L·atm}}{\text{mol·K}} = 62.4 \frac{\text{L·torr}}{\text{mol·K}}
\]

\[
\frac{PV_1}{T_1} = \frac{PV_2}{T_2}
\]

Molar volume = 22.4 L/mol at 0°C and 1 atm 
1 atm = 760 torr (mm Hg) = 101.3 kPa = 14.7 psi

A compound is probably soluble if it contains one of the following:

cations: Group 1A: K⁺, Na⁺, K⁺, Rb⁺, Cs⁺, and NH₄⁺

anions: Halides: Cl⁻, Br⁻, I⁻ (except Ag⁺, Hg²⁺, and Pb²⁺)

NO₃⁻, ClO₄⁻, and acetate (CH₃COO⁻)

SO₄²⁻ (except Ba²⁺, Hg²⁺, and Pb²⁺)

Sulfates of Ag⁺ and Ca²⁺ are slightly soluble
Hydroxides of Ba²⁺, Sr²⁺, and Ca²⁺ are slightly soluble

-Please do not remove this page from the test.

Multiple Choice (72 pts) 

Problems (28 pts) 

Extra Credit (3 pts) 

TOTAL (100 pts)
CHEM 101: GENERAL CHEMISTRY
TEST #3    FALL 2005
MULTIPLE CHOICE QUESTIONS
Mark the correct (best) answer on the score sheet provided. 3 points each.

1. Based on the following reaction, which statement is true?
   \[ \text{N}_2 + \text{O}_2 + 43.2 \text{ kcal} \rightarrow 2\text{NO} \]
   a) 43.2 kcal are consumed when 1.00 g of \text{N}_2 reacts.
   b) 43.2 kcal are consumed when 1.00 g of \text{O}_2 reacts.
   c) 43.2 kcal are consumed when 1.00 mol of \text{N}_2 reacts.
   d) 43.2 kcal are consumed when 1.00 mol of \text{NO} is produced.

2. Consider the reaction:
   \[ \text{C}_6\text{H}_5 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O} + \]
   for which \( \Delta H = -488 \text{ kcal} \)
   We can say that this reaction is ____ and that energy is ____.
   a) endothermic, absorbed
   b) exothermic, released
   c) endothermic, released
   d) exothermic, absorbed

3. The following reaction occurs when baking soda is heated:
   \[ 2\text{NaHCO}_3(s) \rightarrow \text{Na}_2\text{CO}_3(s) + \text{CO}_2(g) + \text{H}_2\text{O}(g) \]
   The entropy change, \( \Delta S \) is ____ because the entropy ____.
   a) positive, decreases
   b) positive, increases
   c) negative, decreases
   d) negative, increases

4. For a reaction to be spontaneous:
   a) The entropy change, \( \Delta S \), must be negative.
   b) The free energy change, \( \Delta G \), must be negative.
   c) The enthalpy change, \( \Delta H \), must be positive.
   d) Both the enthalpy change and entropy change must be positive.

5. Under correct conditions of pressure and temperature, \( \text{H}_2\text{(g)} \) and \( \text{O}_2\text{(g)} \) can be mixed together indefinitely, even though the reaction is very exothermic and will proceed explosively when ignited. The mixture is stable because
   a) the equilibrium constant lies far towards the reactants.
   b) the forward and reverse reaction rates are equal under the conditions stated.
   c) the activation barrier for the reaction is too large for the molecules to overcome under the given conditions.
   d) the reaction mixture requires a catalyst.

6. Reaction rates are determined by all of the following factors except:
   a) the number of collisions between molecules.
   b) the orientation of molecules during collisions.
   c) the spontaneity of the reaction.
   d) the activation energy of the reaction.

7. Which of the following would lower the rate of a reaction?
   a) Adding more reactant.
   b) Lowering the temperature.
   c) Removing some of the product.
   d) Adding a catalyst.

8. When a reaction system is at equilibrium
   a) the reaction rate in the forward direction is at a maximum.
   b) the rates of the forward and reverse reactions are equal.
   c) there is no chemistry happening.
   d) the amounts of reactants and products are equal.

9. The dissociation of acetic acid in water is a common acid-base reaction:
   \[ \text{H}_3\text{CCO}_2\text{H} \leftrightarrow \text{H}^+ + \text{H}_3\text{CCO}_2^- \]
   The expression for the equilibrium constant is:
   a) \( K = \frac{[\text{H}^+][\text{H}_3\text{CCO}_2^-]}{[\text{H}_3\text{CCO}_2\text{H}]} \)
   b) \( K = [\text{H}_3\text{CCO}_2\text{H}][\text{H}^+][\text{H}_3\text{CCO}_2^-] \)
   c) \( K = \frac{[\text{H}^+][\text{H}_3\text{CCO}_2\text{H}]}{[\text{H}_3\text{CCO}_2^-]} \)
   d) \( K = \frac{[\text{H}_3\text{CCO}_2\text{H}]}{[\text{H}^+][\text{H}_3\text{CCO}_2^-]} \)
10. The position of the equilibrium for a reaction system where \( K = 4.6 \times 10^{15} \) can be described as being favored to the ___; the concentrations of products is relatively _____.
   a) left, small  
   b) right, small  
   c) left, large  
   d) right, large

11. Below is the reaction between oxygen and ozone:
   \[ 3 \text{O}_2(g) \leftrightarrow 2 \text{O}_3(g) \]
   for which \( \Delta H = +68 \text{ kcal} \) and \( K = 3 \times 10^{-29} \).
   What is the effect of adding \( \text{O}_3 \)?
   a) The reaction is unchanged.  
   b) The reaction shifts to the right.  
   c) The reaction shifts to the left.  
   d) The value of \( K \) decreases.

12. Which transformation is called condensation?
   a) gas \( \rightarrow \) solid  
   b) solid \( \rightarrow \) liquid  
   c) gas \( \rightarrow \) liquid  
   d) liquid \( \rightarrow \) solid

13. Which transformation is sublimation?
   a) liquid \( \rightarrow \) solid  
   b) liquid \( \rightarrow \) gas  
   c) solid \( \rightarrow \) liquid  
   d) solid \( \rightarrow \) gas

14. Which of the following assumptions of the kinetic-molecular theory of gases best explains why a balloon collapses when put into liquid nitrogen \( (T = 77 \text{ K}) \)?
   a) Gas molecules move at random with no attractive forces between them.  
   b) The speed of the gas molecules is proportional to the Kelvin temperature.  
   c) Energy is conserved when molecules collide with each other or the container walls.  
   d) There is a large amount of empty space between the gas molecules.

15. Recently, the atmospheric pressure in Dordt's physics lab was measured to be 723 mm Hg. This pressure is equivalent to
   a) 1.05 kPa  
   b) 106 kPa  
   c) 5424 kPa  
   d) 96.4 kPa

16. For a fixed amount of gas at a constant temperature, if the volume of a container is doubled, the pressure in the container will
   a) double.  
   b) stay the same.  
   c) decrease by half.  
   d) decrease by 75%.

17. Three identical containers contain one mole of \( \text{CH}_4, \text{O}_2, \) and \( \text{CO}_2 \), respectively, at STP. The container with the greatest mass is:
   a) \( \text{CH}_4 \)  
   b) \( \text{O}_2 \)  
   c) \( \text{CO}_2 \)  
   d) all have the same mass

18. Which of the following pairs of molecules will have the strongest dipole-dipole interactions?
   a) \( \text{NH}_3 \) and \( \text{CH}_4 \)  
   b) \( \text{H}_2\text{O} \) and \( \text{NH}_3 \)  
   c) \( \text{CH}_4 \) and \( \text{CO}_2 \)  
   d) \( \text{H}_2\text{O} \) and \( \text{CH}_4 \)

19. Which of the following molecules cannot hydrogen bond in any form?
   ![Molecule A]  
   ![Molecule B]  
   ![Molecule C]  
   ![Molecule D]
20. At high altitude water boils at 95°C instead of 100°C as at sea level because
   a) gravity is weaker.
   b) the climate is cooler.
   c) atmospheric pressure is greater.
   (d) atmospheric pressure is lower.

21. A solid that has no definite crystal structure and a poorly defined melting point is _____.
   (a) amorphous
   b) molecular.
   c) ionic.
   d) metallic

22. Consider the following four liquids:
   1. water: highly polar, H-bonding
   2. butanol: slightly polar, some H-bonding
   3. chloroform: slightly polar, no H-bonding
   4. octane: nonpolar, no H-bonding
   Which pair of liquids is not mutually soluble?
   a) water and butanol
   (b) water and octane
   c) butanol and chloroform
   d) chloroform and octane

23. The rule of thumb, like dissolves like, is illustrated by the observation(s) that:
   a) nonpolar substances dissolve in hexane (C₆H₁₄).
   b) many ionic compounds dissolve in water.
   c) vegetable oil and water cannot be made into a homogeneous solution.
   (d) all of the above.

24. 100 mL of a solution containing 1.0 g/L of sucrose is diluted to 500 mL. The final concentration will be
   a) 0.10 g/L
   (b) 0.20 g/L
   c) 1.0 g/L
   d) 5.0 g/L
25. Draw and describe a reaction energy diagram for a spontaneous reaction where the activation energy has a value approximately equal to the free energy change. Show how the diagram changes when a catalyst is added to the reaction.
26. A sample of helium has a volume of 560 mL at 298.0 K and 450 torr. The temperature is changed to -23.0°C and the volume changed to 1.08 L. What is the new pressure (in atm)?

\[ \frac{p_1 \cdot V_1}{T_1} = \frac{p_2 \cdot V_2}{T_2} \]

\[ p_2 = \frac{p_1 \cdot V_1 \cdot T_2}{T_1 \cdot V_2} = \frac{(450 \text{ torr})(560 \text{ mL})(250.0 \text{ K})}{(298 \text{ K})(1080 \text{ mL})} = 195.75 \text{ torr} \times \frac{1 \text{ atm}}{760 \text{ torr}} \]

\[ = 0.257 \text{ atm} \]
27. a) How would you prepare 250.0 mL of a 0.50% (w/v) boric acid (B(OH)₃) given solid boric acid, water, and any containers you might need?
   b) What is the molar concentration of this solution?

\[
\text{B(OH)}_3 = 10.81 \times 3(1.59994 \div 100794) = 61.83 \text{ g/mol}
\]

\[
0.50\% = \frac{0.50 \text{ g}}{100 \text{ mL}} \times 250 \text{ mL} = 1.25 \text{ g B(OH)}_3 \text{ needed}
\]

\[
\frac{1.25 \text{ g}}{61.83 \text{ g}} \times \frac{1 \text{ mol}}{0.250 \text{ L}} = 0.0809 \frac{\text{ mol}}{\text{ L}}
\]

Take 1.25 g B(OH)₃ and dissolve in enough H₂O to make 250.0 mL of solution.