Name:_____ Score:_____/100

Part I. Multiple choice. Write the letter of the correct answer for each problem. 3 points each

1. Which of the following pairs of substances is *least likely* to form a solution?
   A) A polar compound in a polar solvent
   B) A nonpolar compound in a nonpolar solvent Answer _____
   C) An ionic compound in a polar solvent
   D) An ionic compound in a nonpolar solvent

2. That energy goes spontaneously from more useful forms to less useful forms is a statement of the:
   A) first law of thermodynamics
   B) second law of thermodynamics Answer _____
   C) third law of thermodynamics
   D) standard law of energy conversion

3. According to the kinetic-molecular theory of gases, in collisions between gas particles, the total energy
   A) decreases slightly. C) increases slightly.
   B) decreases considerably. D) remains the same. Answer _____

4. One 1.00L flask (flask A) contains CO gas and another 1.00 L flask (flask B) contains CO_2 gas. If both flasks are at the same temperature and pressure, flask A contains
   A) more mass but the same number of molecules than flask B.
   B) more mass and more molecules than flask B. Answer _____
   C) less mass and fewer molecules than flask B.
   D) less mass but the same number of molecules than flask B.

5. Which of the following contains the greatest number of moles of O?
   A) 2.3 mol H_2O C) 1.2 mol H_2O_2
   B) 0.9 mol $NaNO_3$ D) 0.5 mol $Ca(NO_3)_2$ Answer _____

6. Argon gas is enclosed in a 10.2 L tank at 12.01 atm. Which of the following is a reasonable value for the pressure when the argon is transferred to a 30.0 L tank at constant temperature?
   A) 3.0 atm C) 36.0 atm
   B) 4.0 atm D) 120.0 atm Answer _____

7. Which intermolecular force is most significant in accounting for the high boiling point of water relative to other substances of similar molar mass?
   A) ion-dipole interactions
   B) hydrogen bonding interactions Answer _____
   C) dipole-induced dipole interactions
   D) dispersion forces

8. The fundamental law that energy cannot be created or destroyed is:
   A) The first law of thermodynamics
   B) The second law of thermodynamics Answer _____
   C) The third law of thermodynamics
   D) The law of the jungle

9. Molecules are farthest apart in a(n)

A) ionic solid C) covalent solid
B) liquid D) gas Answer _____

10. Consider the reaction below. How many moles of CO_2 are produced if 50 moles of O_2 react?

$$2\ C_8H_{18} + 25\ O_2 \rightarrow 16\ CO_2 + 18\ H_2O$$

A) 50 C) 48
B) 100 D) 32 Answer _____

11. Which of the following is likely to require the greatest input of energy to melt, therefore having the highest melting point?

A) $C_6H_{12}O_6$ C) NaCl
B) N_2O D) Ar Answer _____

12. Reactions tend to proceed faster at higher temperatures because

A) the energy of the products has increased.
B) the pressure in the reaction vessel has decreased. Answer _____
C) there are more molecules available to react.
D) reactant molecules collide more frequently.

13. How many grams of sulfur are in 0.20 mol of $Cr(SO_4)_3$?

A) 3.20 g C) 12.8 g
B) 6.40 g D) 19.2 g Answer _____

14. In the reaction $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$, with all the substances at the same temperature and pressure, what volume of ammonia is produced when 2.25 L of nitrogen reacts with excess hydrogen?

A) 2.25 L C) 9.00 L
B) 4.50 L D) 13.5 L Answer _____

15. Of CH_3OH, H_2, HF, and H_2O, which molecule(s) can participate in hydrogen bonding?

A) H_2 only C) CH_3OH, HF, and H_2O
B) H_2O only D) CH_3OH, H_2, HF, and H_2O Answer _____

Part II. Complete each of the following. Point values are noted by each question.

16. Complete the following table. (6 points)

_____ g C_4H_{10}	=	6.14 mol C_4H_{10}	=	_____ molecules C_4H_{10}

17. Match the term with its definition. (8 points)

_____ thermodynamics	A. the tendency for an atom in a bond to attract electrons to itself.
_____molarity	B. a process that releases heat energy
_____solute	C. a process that absorbs heat energy
_____exothermic	D. a thermodynamic concept that does not depend on pathway (or mechanism).
_____electronegativity	E. the substance that is dissolved in another substance to form a solution
_____joule	F. the substance that dissolves another substance to form a solution
_____ enthalpy	G. energy transferred as heat
_____ state function	H. concentration in terms of moles per liter
	I. a quantity of energy
	J. the study of energy and its changes

18. How would you prepare 350 g of an aqueous solution that is 3.50% glucose ($C_6H_{12}O_6$) by mass, starting with pure, solid glucose? (6 points)

19. How does the statement "you can't break even" relate to the second law of thermodynamics? (6 points)

20. In a laboratory experiment, you use 25 mL of 2.0 M sodium hydroxide solution to begin the alloy formation. How many grams of NaOH are present in 25 mL of 2.0 M NaOH? (6 points)

Part III. ***Complete 3 of the following 4 problems.*** Clearly mark the problem you do not want graded. Each problem is worth eight (8) points. You must show you work on calculations to receive partial credit. Report numerical results to the correct number of significant figures and with the appropriate units.

21. Nitroglycerin, $C_3H_5(ONO_2)_3$, is a contact explosive that undergoes a rapid decomposition to form carbon dioxide, water vapor, nitrogen gas and oxygen gas.
    a. Balance the reaction for the decomposition of nitroglycerin. I've given you a coefficient of 4 for nitroglycerin as a starting point.

$$4\ C_3H_5(ONO_2)_3\,(s) \rightarrow \_\_\_\_ CO_2\,(g) + \_\_\_\_ H_2O\,(g) + \_\_\_\_ N_2\,(g) + \_\_\_\_ O_2\,(g)$$

    b. What is the molar mass of nitroglycerin?

    c. If 20.0 grams of nitroglycerin decomposes, how many total moles of gas are produced?

    d. Assuming the 20.0 grams of nitroglycerin from part c decomposes in a closed metal pipe with a volume of 0.200 L at a temperature of 5000°C (typical for nitroglycerin), what will the pressure be inside the pipe?

22. At a temperature of -100°C, tetrafluoromethane (CF_4) is a gas, while water is a solid. Use your understanding of the structure of these two compounds to explain this difference in their physical properties.

23. Calculate the amount of energy that is involved when 1 mol of nitrogen gas reacts with 3 mol hydrogen gas to produce 2 mol ammonia gas, given the information below. *(Hint: start with a Lewis structure for each compound.)*

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

Bond	Bond Energy (kJ/mol)
N-N	163
N=N	418
N≡N	964
N-H	391
H-H	432

24. Oxygen gas (O_2) and nitrogen gas (N_2) can react to form nitrogen dioxide. What mass of oxygen is needed to react with 1.50 grams nitrogen in this process?

% by mass = $\frac{\text{g component}}{\text{100 g mixture}}$	R = 0.0821 (L atm)/(mol K)	$\frac{P_1}{T_1} = \frac{P_2}{T_2}$	$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$
At STP, P = 1 atm, T = 25°C	K = °C + 273.15	$\frac{V_1}{T_1} = \frac{V_2}{T_2}$	PV=nRT
Avogadro's number: $N_A = 6.022 \times 10^{23}$ mol^{-1}	d = m/v	$P_1V_1 = P_2V_2$	

To save some calculation time, you may round atomic masses to two (2) decimal points.