

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 contains the greatest number of moles of O?
A) 2.3 mol H₂O
B) 1.2 mol H₂O₂
C) 0.9 mol NaNO₃
D) 0.5 mol Ca(NO₃)₂
Answer _____
2. 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
B) 4.0 atm
C) 36.0 atm
D) 120.0 atm
Answer _____
3. Which intermolecular force is most significant in accounting for the high boiling point of water relative to other substances of similar molar mass?
A) dispersion forces
B) dipole-induced dipole interactions
C) hydrogen bonding interactions
D) ion-dipole interactions
Answer _____
4. The fundamental law that energy cannot be created or destroyed is:
A) The first law of thermodynamics
B) The second law of thermodynamics
C) The third law of thermodynamics
D) The law of the jungle
Answer _____
5. Which of the following pairs of substances is least likely to form a solution?
A) An ionic compound in a nonpolar solvent
B) An ionic compound in a polar solvent
C) A nonpolar compound in a nonpolar solvent
D) A polar compound in a polar solvent
Answer _____
6. 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
C) third law of thermodynamics
D) standard law of energy conversion
Answer _____
7. According to the kinetic-molecular theory of gases, in collisions between gas particles, the total energy
A) decreases slightly.
B) decreases considerably.
C) increases slightly.
D) remains the same.
Answer _____
8. One 1.00L flask (flask A) contains CO gas and another 1.00 L flask (flask B) contains CO₂ gas. If both flasks are at the same temperature and pressure, flask A contains
A) less mass and fewer molecules than flask B.
B) less mass but the same number of molecules than flask B.
C) more mass but the same number of molecules than flask B.
D) more mass and more molecules than flask B.
Answer _____

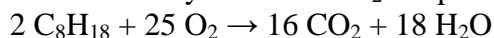
9. Molecules are farthest apart in a(n)

- A) ionic solid
B) liquid

- C) covalent solid
D) gas

Answer _____

10. Consider the reaction below. How many moles of CO_2 are produced if 75 moles of O_2 react?



- A) 50
B) 100

- C) 48
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) $\text{C}_6\text{H}_{12}\text{O}_6$
B) N_2O

- C) NaCl
D) Ar

Answer _____

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

- A) H_2 only
B) H_2O only

- C) CH_3OH , HF , and H_2O
D) CH_3OH , H_2 , HF , and H_2O

Answer _____

13. Reactions tend to proceed faster at higher temperatures because

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

Answer _____

14. How many grams of sulfur are in 0.20 mol of $\text{Cr}(\text{SO}_4)_3$?

- A) 3.20 g
B) 6.40 g

- C) 12.8 g
D) 19.2 g

Answer _____

15. In the reaction $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$, with all the substances at the same temperature and pressure, what volume of ammonia is produced when 4.50 L of nitrogen reacts with excess hydrogen?

- A) 2.25 L
B) 4.50 L

- C) 9.00 L
D) 13.5 L

Answer _____

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

16. Complete the following table. (6 points)

_____ g C_5H_{11}	=	8.14 mol C_5H_{11}	=	_____ molecules C_5H_{11}
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17. Match the term with its definition. (8 points)

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

18. In a laboratory experiment, you use 15 mL of 3.0 M sodium hydroxide solution to begin the alloy formation. How many grams of NaOH are present in 15 mL of 3.0 M NaOH? (6 points)

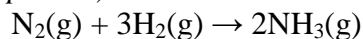
19. How does the statement “you can’t break even” relate to the second law of thermodynamics? (6 points)

20. How would you prepare 250 g of an aqueous solution that is 4.50% glucose ($C_6H_{12}O_6$) by mass, starting with pure, solid glucose? (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 your work on calculations to receive partial credit. Report numerical results to the correct number of significant figures and with the appropriate units.

21. 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?

22. 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.*)

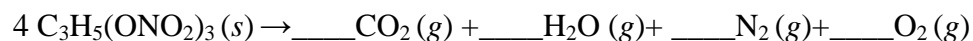


Bond	Bond Energy (kJ/mol)
N-N	163
N=N	418
N \equiv N	964
N-H	391
H-H	432

23. 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.

24. Nitroglycerin, $\text{C}_3\text{H}_5(\text{ONO}_2)_3$, 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.



- 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?

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

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

Periodic Table of the Elements

1 1A H Hydrogen 1.008	2 2A He Helium 4.003	3 3B Li Lithium 6.941	4 4B Be Beryllium 9.012	5 5B B Boron 10.811	6 6B C Carbon 12.011	7 7B N Nitrogen 14.007	8 8B O Oxygen 15.999	9 9B F Fluorine 18.998	10 10B Ne Neon 20.180	11 11B Na Sodium 22.990	12 12B Mg Magnesium 24.305	13 13B Al Aluminum 26.982	14 14B Si Silicon 28.086	15 15B P Phosphorus 30.974	16 16B S Sulfur 32.066	17 17B Cl Chlorine 35.453	18 18B Ar Argon 39.948	19 19B K Potassium 39.098	20 20B Ca Calcium 40.078	21 21B Sc Scandium 44.956	22 22B Ti Titanium 47.867	23 23B V Vanadium 50.942	24 24B Cr Chromium 51.996	25 25B Mn Manganese 54.938	26 26B Fe Iron 55.845	27 27B Co Cobalt 58.933	28 28B Ni Nickel 58.693	29 29B Cu Copper 63.546	30 30B Zn Zinc 65.38	31 31B Ga Gallium 69.723	32 32B Ge Germanium 72.631	33 33B As Arsenic 74.922	34 34B Se Selenium 78.971	35 35B Br Bromine 79.904	36 36B Kr Krypton 83.798	37 37B Rb Rubidium 85.468	38 38B Sr Strontium 87.62	39 39B Y Yttrium 88.906	40 40B Zr Zirconium 91.224	41 41B Nb Niobium 92.906	42 42B Mo Molybdenum 95.95	43 43B Tc Technetium 98.907	44 44B Ru Ruthenium 101.07	45 45B Rh Rhodium 102.906	46 46B Pd Palladium 106.42	47 47B Ag Silver 107.868	48 48B Cd Cadmium 112.414	49 49B In Indium 114.818	50 50B Sn Tin 118.711	51 51B Sb Antimony 121.760	52 52B Te Tellurium 127.6	53 53B I Iodine 126.904	54 54B Xe Xenon 131.294	55 55B Cs Cesium 132.905	56 56B Ba Barium 137.328	57-71 Lanthanide Series	72 72B Hf Hafnium 178.49	73 73B Ta Tantalum 180.948	74 74B W Tungsten 183.84	75 75B Re Rhenium 186.207	76 76B Os Osmium 190.23	77 77B Ir Iridium 192.217	78 78B Pt Platinum 195.085	79 79B Au Gold 196.967	80 80B Hg Mercury 200.592	81 81B Tl Thallium 204.383	82 82B Pb Lead 207.2	83 83B Bi Bismuth 208.980	84 84B Po Polonium [208.982]	85 85B At Astatine [209.987]	86 86B Rn Radon [222.018]	87 87B Fr Francium 223.020	88 88B Ra Radium 226.025	89-103 Actinide Series	104 104B Rf Rutherfordium [261]	105 105B Db Dubnium [262]	106 106B Sg Seaborgium [266]	107 107B Bh Bohrium [264]	108 108B Hs Hassium [269]	109 109B Mt Meitnerium [278]	110 110B Ds Darmstadtium [281]	111 111B Rg Roentgenium [280]	112 112B Cn Copernicium [285]	113 113B Nh Nihonium [286]	114 114B Fl Flerovium [289]	115 115B Mc Moscovium [289]	116 116B Lv Livermorium [293]	117 117B Ts Tennessine [294]	118 118B Og Oganesson [294]	119-120 Lanthanide Series	121 121B La Lanthanum 138.905	122 122B Ce Cerium 140.116	123 123B Pr Praseodymium 140.908	124 124B Nd Neodymium 144.243	125 125B Pm Promethium [144.913]	126 126B Sm Samarium 150.36	127 127B Eu Europium 151.964	128 128B Gd Gadolinium 157.25	129 129B Tb Terbium 158.925	130 130B Dy Dysprosium 162.500	131 131B Ho Holmium 164.930	132 132B Er Erbium 167.255	133 133B Tm Thulium 168.934	134 134B Yb Ytterbium 173.055	135 135B Lu Lutetium 174.967	136-140 Actinide Series	141 141B Ac Actinium 227.028	142 142B Th Thorium 232.038	143 143B Pa Protactinium 231.036	144 144B U Uranium 238.029	145 145B Np Neptunium 237.048	146 146B Pu Plutonium 244.064	147 147B Am Americium 243.061	148 148B Cm Curium 247.070	149 149B Bk Berkelium 247.070	150 150B Cf Californium 251.080	151 151B Es Einsteinium [254]	152 152B Fm Fermium 257.085	153 153B Md Mendelevium 258.10	154 154B No Nobelium 259.101	155 155B Lr Lawrencium [262]
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