Directions

1. Skim the entire exam before you begin so that you have a sense of the whole: what parts you can do quickly and what parts will require more time. The points for each problem are shown in parenthesis in the left margin. Try to use your time in proportion to the points assigned for each question.
2. You must show all the work necessary to arrive at your answer. **No credit will be given for numerical answers unless your work is shown.** (We want to be able to follow your thought process in order to be able to help make corrections and allot partial credit.)
3. Be sure to include the correct number of significant figures and the appropriate unit when reporting your answers.

Academic Integrity Pledge

During the exam I will

- turn off my cell phone and put it away (out of sight and not on my person)
- close all books, notebooks, etc. and put them under the seat in which I sit
- use only a permitted calculator
- keep my eyes down and focused on my own paper
- write only in ink
- keep my answers covered
- sit in the area assigned to my section
- stop writing when the end of the exam is announced

During the exam I will not

- have any papers other than those provided
- have any writing on my clothing or person or desk
- talk to anyone other than a TA or the instructor

I understand that the ***minimum consequence*** of any behavior contrary to this pledge is that I will receive a ***zero on this exam*** that will not be replaced by the percent earned on my final exam.

Name (sign)_____

Scoring

1	14 / 15	5	15 / 15	MC	30 /30
2	0 / 15	6	3 / 15		
3	14 / 15	7	B / 15	Total	103 /150
4	15 / 15	8	4 / 15		

Multiple Choice Answers

1.	D	3.	E	5.	B
2.	B	4.	B	6.	A

1. Some commercial drain cleaners contain two components: sodium hydroxide and aluminum powder. When the mixture is poured down a clogged drain, the following reaction occurs:

$$2NaOH(aq) + 2Al + 6H_2O(l) \rightarrow 2NaAl(OH)_4(aq) + 3H_2(g)$$

The heat generated in this reaction helps melt away obstructions such as grease. The hydrogen gas released stirs up the solids clogging the drain.
Calculate the volume of hydrogen formed at STP when 25.7 g NaOH reacts completely with excess aluminum.

MOLAR MASSES:

NaOH............39.997 g/mol	$NaAl(OH)_4$....117.9995 g/mol
Al..................26.9815 g/mol	H_2.....................2.016 g/mol
H_2O...............18.015 g/mol	

STP ⇒ T = 273.15 K
P = 1 atm
V_{H_2} = ?
M_{H_2} = 2.016 g/mol
n_{H_2} = ?
R = 0.08205783

m_{NaOH} = 25.7 g
M_{NaOH} = 39.997 g/mol
$n_{NaOH} = \frac{m}{M}$ = 0.642548191 mol

$n_{H_2} = \frac{0.642548191}{2} \times 3$ → 0.963822286

PV = nRT
(1)(V) = (0.963822286)(0.08205783)(273.15)
V = 21.6033 L ← → 5SD, Mm of NaOH.

2. A piece of sodium metal undergoes complete reaction with water as follows:

$$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$$

The vapor pressure of water at 25°C is 0.0313 atm. If 186 mL of hydrogen are collected at 1.05 atm and 25°C, how many grams of sodium reacted?

V = 0.186 L
P = 1.05 − 0.0313 atm
T = 25 + 273.15
R = 0.08205783
Solve for n and mole ratio
use $n_{Na} = \frac{m}{M_{Na}}$

(3SD)

VP_{H_2O} = 0.0313 atm
V_H = 0.186 L
P = 1.05 atm
T = 25 + 273.15 = 298.15 K
$n = \frac{m}{M}$ Na = ?

for water
PV = nRT

~~(0.0313)(0.186)~~ = (n_{H_2O})(0.08205783)(298.15)

~~= 0.0109412~~
~~= 0.01099~~

n_{H_2} = 0.000237959 × 2

n_{Na} = (0.000237959) × 2

m = n M_{Na} → 22.989
(~~0.000237959~~)(22.98976928)
(0.000475918)
m = ~~0.00547…~~ g
= ~~0.00547 g~~

0.241

3. The density of a 4.25 *m* aqueous solution of methanol, CH_3OH, is 0.973 g/mL. What is the molarity of the solution? The molar mass of methanol is 32.04 g/mol.

Solute	Solvent	Soln
$n = 4.25\,m$	$1000\,g = 1\,kg$	$d = 0.973\,g/mL$
$M_{CH_3OH} = 32.04$		$d = \frac{m}{V} \rightarrow \frac{1000+136.17}{V}$
$m = nM = 136.17$		$V = \frac{m}{d} = \frac{1136.17}{0.973}$
		$V = 1167.697\,mL$

$C = \frac{n}{V}$

$C = \frac{4.25}{V} = \frac{4.25}{1.16769}$ $= 1.1676978 42$

$= 3.639640195\ g/L$

$= \boxed{3.64\ g/L}$

4. A 202-mL benzene solution containing 2.47 g of an organic polymer has an osmotic pressure of 8.63 mmHg at 21°C. Calculate the molar mass of the polymer.

$V_{soln} = 202\,mL = 0.202\,L$

$m_{solute} = 2.47\,g$

$T = 21^\circ C + 273.15 = 294.15$

$P = \frac{8.63\,mmHg}{760} = 0.011365263\ atm$

~~$\Pi = MRT \rightarrow \left(\frac{8.63}{760}\right) = M(0.08205783)(294.15)$~~

$V = 202\,mL$ ✓
$m = 2.47\,g$ ✓
$P = 8.63\,mmHg$ ✓
$T = 21^\circ C$ ✓
$MM = ?$

$PV = nRT$

$PV = (n_{solute})(R)(T)$

$PV = \frac{m_{solute}}{M_{solute}}(R)(T)$

$(0.011365263)(0.202) = \frac{2.47}{M}(0.08205783)(294.15)$

$0.000095029 = 2.47/M$

$M = 25991.85449 = \boxed{2.60 \times 10^4\ g/mol}$

$n = \frac{m}{M}$

$M = \frac{m}{n}$

5. Calculate the root-mean-square velocity for the SO_2 molecules in a sample of SO_2 gas at STP.

$RMS = \sqrt{\frac{3RT}{M_{SO_2}}}$ $R = 8.314510 \frac{J}{mol \cdot K}$

$= \sqrt{\frac{3(8.314510)(273.15)}{0.0640638}}$ $T = 273.15 K$

$M_{SO_2} = (32.065) + 2(15.9994) = 64.0638$ g/mol

$64.0638/1000 = 0.0640638$ kg/mol

$= 326.117$ m/s $=$ 326.18 m/s (5 SD (Mm dg))

6. In a certain mountain range, water boils at 94°C. What is the atmospheric pressure under these conditions? The enthalpy of vaporization, ΔH_{vap}, for water is 40700 J/mol.

$\Delta H_{vap} = 40700$ J/mol $T = 94 + 273.15 = 367.15$ (T_2)

$\ln\left[\frac{P_2}{P_1}\right] = \frac{-\Delta H_{vap}}{R}\left[\frac{1}{T_2} - \frac{1}{T_1}\right]$ $P_2 = ?$

Only one temp/pressure

$P_1 = 1$ atm

$T_1 = 100°C$ normally

$T_2 = 94°C$

$P_2 = P_2$?

$\ln[P] = \frac{-40700}{8.314510}\left[\frac{1}{367.15}\right]$

$e^{\ln P} = e^{-13.33258057}$

$P = 0.00000162$ atm

7. a. Circle the compound that has the lowest vapor pressure at room temperature.

highest BP

Si_3H_8	Si_2H_6	Si_2Cl_6	Si_4H_{10}	SiH_4
92.322	62.22	268.89	122.424	32.118

b. Circle the compound with the lowest standard enthalpy of vaporization, ΔH_{vap}, at 25°C.

lowest BP, IMF

lowest Mmass

Si_3H_8	Si_2H_6	Si_2Cl_6	Si_4H_{10}	SiH_4
92.3205	62.219	268.889	122.422	32.1125

c. At 25°C, the vapor pressure of diethyl ether $(CH_3CH_2)_2O$) is higher than the vapor pressure of its isomer *n*-butanol, $CH_3CH_2CH_2CH_2OH$. Explain.

A higher VP means a lower boiling point, so diethyl ether has a lower BP than n-butanol. This is because n-butanol has an OH in it, meaning oxygen and hydrogen are hydrogen bonding, which is a strong intermolecular force, and increases the BP. Diethyl ether does not have any hydrogen bonding.

d. Why is the vapor pressure of a solution always less than that of the pure solvent?

Lower VP = Higher Boiling point

Higher VP = Lower BP

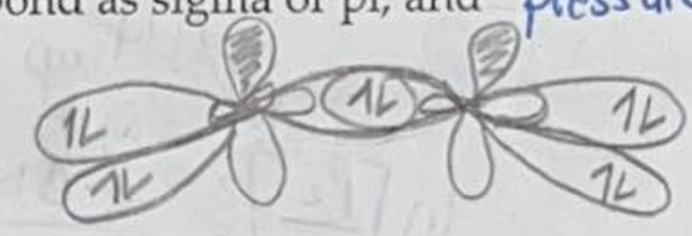
Because the solute molecules on surface and soln cause VP is the pressure of a gas above a liquid. There is always more solution than solvent, and the VP is lower for the solution because it has solvent+solute mixed in. Pure solvent has a higher VP because it is only one pure substance and the moles will be less, which makes higher pressure.

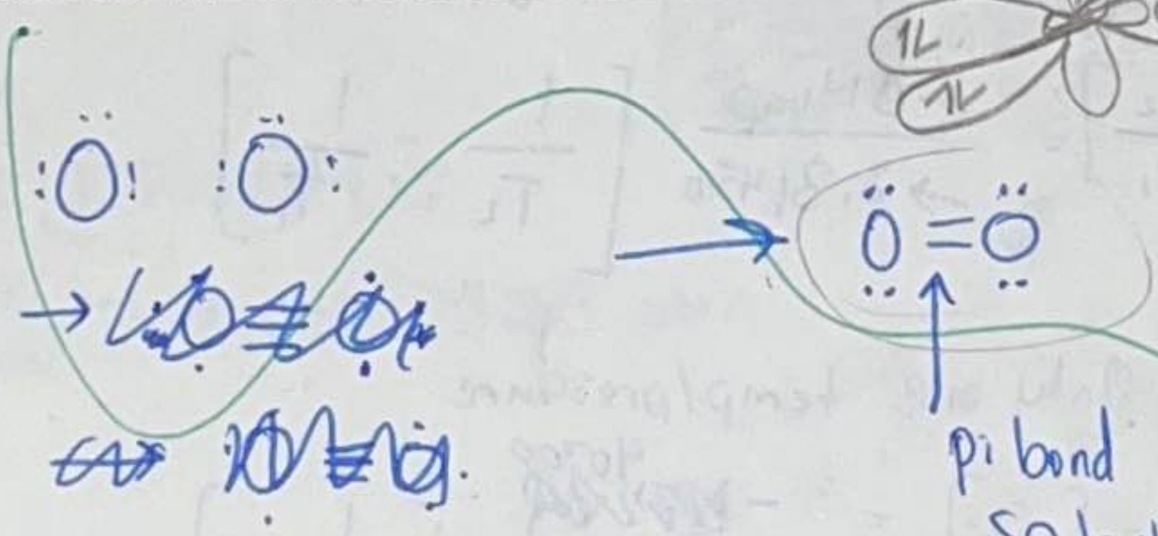
Because the solute molecules on surface and soln cause the soln to have greater molarity which results in ↓VP

$P_{gas} = nRT$

$P_{gas} = \frac{n}{V}RT$

8. a. Draw the Lewis structure for the O_2 molecule. Explain each bond as sigma or pi, and include the orbital from each atom used to form each bond.





b. What charges does thallium, Tl, take when it forms cations?

+1, +3

What charges does tin, Sn, take when it forms cations?

+4, +2

Write the valence electron configuration for the Mo^+ ion.

$[Kr]\,5s^2\,4d^3$

$= (Kr)\,5s^1\,4d^4$

half filled shell is better than a shell with 3