**Chemistry 1A**
**Professor Pines**

**Midterm Exam 1**
**(Closed Book, 75 minutes, 50 points)**

**September 20, 1995**


**Name:**_____ **Discussion TA:**_____

**SID:**_____ **Lab Section:**_____

Identification Sticker

**Possibly Useful Information:**

Absolute T(K) = T(°C) + 273.15

1.000 atm = 760.0 torr

STP is 273.15 K, 1.00 atm

$N_0 = 6.0221 \times 10^{23}$ mol$^{-1}$

Ideal Gas: PV = nRT

$V_m = 22.414$ L·mol$^{-1}$ (for an ideal gas)

$R = 0.08206$ L atm mol$^{-1}$ K$^{-1}$

$u_{rms} = \sqrt{\overline{u^2}} = \sqrt{\frac{3RT}{M}}$

$P = \frac{Nm\overline{u^2}}{3V}$

$E_{kinetic} = \frac{nN_0m\overline{u^2}}{2} = \frac{3}{2}nRT$

$\overline{\epsilon_k} = \frac{1}{2}m\overline{u^2} = \frac{E_k}{N_0}$

tetrahedral angle (e.g. H-C-H in $CH_4$ ) =109.5°

**Test-taking strategy: PLEASE READ THIS FIRST**

Write your name on all 6 pages. This test consists of three parts: multiple choice, short answers, and problems requiring a longer answer. In order to maximize your score on the exam:

- Do the questions you know how to do first.
- Then, go back and spend more time on the questions you find more challenging.
- Budget your time carefully---don't spend too much time on one problem.
  Anticipate spending about 20 minutes on each section.
- Don't forget to include units!

**Page**

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 NAME_____

**Part I: Multiple Choice, 2 points each, 20 points total**
**CIRCLE THE CORRECT ANSWER OR ANSWERS FOR EACH QUESTION**

**1.)** In the combustion of butane ($C_4H_{10}$) in excess $O_2$ to give $CO_2$ and $H_2O$, how many moles of $CO_2$ are formed from each mole of butane?

1 2 3 4 5

**2.)** The total kinetic energy of 1.0 mole of argon (Ar) gas at 420 K is 5.2 kJ. What is the total kinetic energy of 1.0 mole of helium (He) gas at the same temperature?

5.2 kJ 1.6 kJ 1.0 kJ 0.52 kJ 0.16 kJ

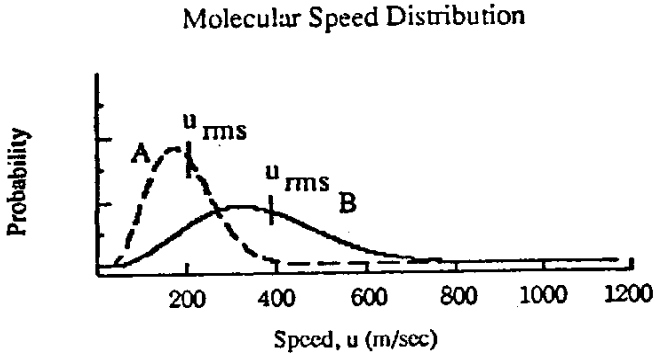
**3.)** The reaction of zinc metal (Zn) with hydrochloric acid (HCl) produces hydrogen gas ($H_2$), according to the equation below. In order to fill a 89.6 liter airbag at STP with hydrogen, how many moles of Zn are required?

$$Zn\,(s) + 2HCl\,(aq) \longrightarrow H_2\,(g) + ZnCl_2\,(aq)$$

1 2 3 4 5

**4.)** At a fixed temperature in a container of a gas, which of the following is true:
a) All molecules have the same kinetic energy
b) Different molecules of the same gas have a range of kinetic energies
c) Large molecules and small molecules move at the same speed
d) The speed of a particular gas molecule is constant
e) None of the above.

**5.)** Curves **A** and **B** in the figure below describe the speed distributions of oxygen molecules. Distribution **A** corresponds to a temperature of 50K. To what temperature does the distribution **B** correspond?




25 K 50 K 141 K 200 K 400 K

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**6.)** If 1 mole of glucose ($C_6H_{12}O_6$) reacts with 1 mole of $O_2$, according to the reaction below,

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$$

which is the limiting reagent in the reaction?

$C_6H_{12}O_6$ $O_2$ $CO_2$ $H_2O$

**7.)** The pressure at sea level is 1.0 atm and for every 10 meters of depth beneath the sea, the pressure increases by 1.0 atm. In which of the following situations would the volume of a balloon decrease from 2.0 liters to 1.0 liter?

a.) going from a depth of 60 meters to 30 meters below sea level
b.) going from a depth of 50 meters to 20 meters below sea level
c.) going from a depth of 0 meters to 20 meters below sea level
d.) going from a depth of 20 meters to 50 meters below sea level
e.) going from a depth of 30 meters to 60 meters below sea level

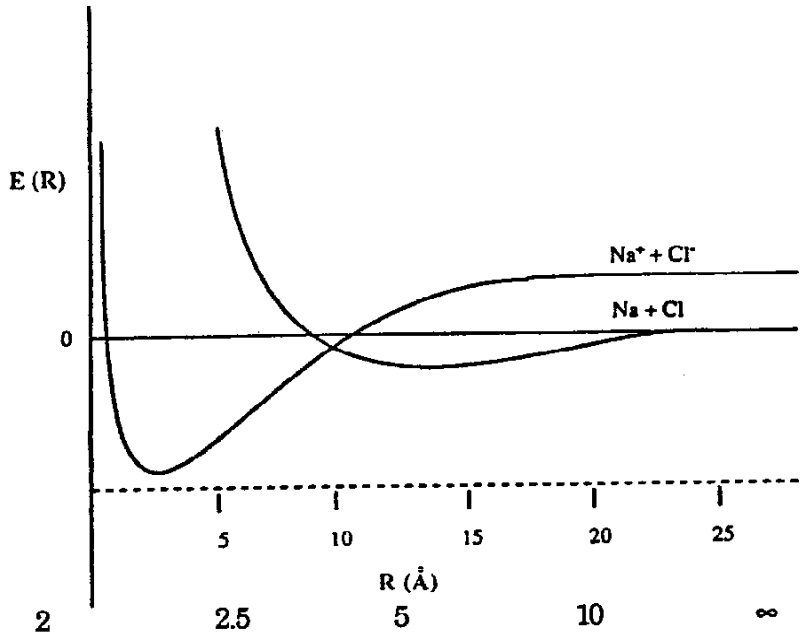
**8.)** Circle all of the species which have been drawn with correct Lewis dot structures:

:C:::O: H:Br: :Cl:::Cl: :O::C::O: H:C:::C:H H:N:H:H

**9.)** An atom of krypton (Kr) will most strongly attract which of the following atoms:

Xe Kr Ar Ne He

**10.)** Given the intermolecular potentials below, at what distance R (in Å) will an electron jump between a sodium and chlorine atom as the atoms approach each other from R = ∞?

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**Part II: Short Answer, 3 points each, 15 total points.**

**1.)** Arrange the following in order of decreasing mass:

4.85 x $10^{22}$ molecules of $BF_3$ 13.62 liters of $O_2$ gas at STP 3.2 grams of $H_2O$

_____ > _____ > _____

greatest mass smallest mass

**2.)** A binary compound of silver and fluorine is 74% silver by mass. Determine the empirical formula of the compound.

**3.)** Indicate how the bond angles change during the reaction: $PH_3 + H^+ \longrightarrow PH_4^+$

**4.)** Give a real-life illustration of the relationship between temperature and gas pressure.

**5.)** Selective precipitation can be used to separate a solution containing multiple cations. You are given a solution which contains $AgNO_3$, $Cu(NO_3)_2$, and $Fe(NO_3)_3$. Your goal is to separate the three cations using the following test reagents: NaOH, NaCl, and $NH_4OH$. You have observed the following reactions:

| | NaOH | NaCl | $NH_4OH$ |
|---|---|---|---|
| $AgNO_3$ | white ppt | white ppt | no reaction |
| $Cu(NO_3)_2$ | blue ppt | no reaction | blue ppt |
| $Fe(NO_3)_3$ | red ppt | no reaction | no reaction |

Given these observations, in what order would you add the test reagents to separate the copper, silver and iron cations as insoluble salts?

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**Part III: Problems, 15 points total**
**SHOW ALL OF YOUR WORK AND USE UNITS IN YOUR CALCULATIONS**

**(7 pts.)**
**1.)** The compounds $CO_2$ and $H_2O$ have vaporization temperatures (the temperature of boiling or sublimation) of -78°C and 100 °C respectively.

**a.)** Draw the Lewis dot structures of the two molecules:

**b.)** Which of these molecules has the lower overall dipole moment (is the least polar)? Use molecular structures to justify your answer.

**c.)** Explain why there is a significant difference in the vaporization temperatures of these two compounds.

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**(9 pts.)**
**1.)** Lithium carbonate ($Li_2 CO_3$) and rubidium carbonate ($Rb_2CO_3$) are both white solids which react with acid ($H_3O^+$) in the following manner:

$$Li_2CO_3\,(s) + H_3O^+\,(aq) \longrightarrow CO_2\,(g) + H_2O\,(l) + Li^+\,(aq)$$

$$Rb_2CO_3\,(s) + H_3O^+\,(aq) \longrightarrow CO_2\,(g) + H_2O\,(l) + Rb^+\,(aq)$$

Suppose you have the following equipment and supplies available:
- a balance to weigh amounts of the solid carbonate samples
- a device to measure the volume of $CO_2$ gas produced in the reaction (in L)
- an unlimited amount of a solution of $H_3O^+$
- several grams of each carbonate compound

**a.)** Balance the above equations.

**b.)** Given unidentified samples of these two carbonates and the above equipment, write a procedure to determine which sample is which. Show your reasoning below. Write your procedure in the box.

| Final Procedure |
| --- |
| |

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