CHEM 1225
Exam II
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March 4, 1999

Name ____________________________

TA's Name ____________________________

Lab Section ________

INSTRUCTIONS:

1. This examination consists of a total of 7 different pages. The last two pages includes a periodic table, a solubility table, a table of equilibrium vapor pressures and some additional useful information. All work should be done in this booklet.

2. PRINT your name, TA's name and your lab section number now in the space at the top of this sheet. DO NOT SEPARATE THESE PAGES.

3. Answer all questions that you can and whenever called for show your work clearly. Your method of solving problems should pattern the approach used in lecture. You do not have to show your work for the multiple choice (if any) or short answer questions.

4. No credit will be awarded if your work is not shown in problems 2, 3 and 5.

5. Point values are shown next to the problem number.

6. Budget your time for each of the questions. Some problems may have a low point value yet be very challenging. If you do not recognize the solution to a question quickly, skip it, and return to the question after completing the easier problems.

7. Look through the exam before beginning; plan your work; then begin.

8. Relax and do well.

	Page 2	Page 3	Page 4	Page 5	TOTAL
SCORES	____ (30)	____ (25)	____ (23)	____ (22)	____ (100)

(6) 1. Write the chemical formula(s) of the product(s) and balance the following reactions. Identify all products phases as either (g)as, (l)iquid, (s)olid or (aq)ueous.

a) **2**Al*(s)* + **2**KOH*(aq)* + **6**H_2O*(l)* → **$2KAl(OH)_4$*(aq)* + $3H_2$*(g)***

b) **2**$Al(OH)_3$*(aq)* + **3**H_2SO_4*(aq)* → **$Al_2(SO_4)_3$*(aq)* + $6H_2O$*(l)***

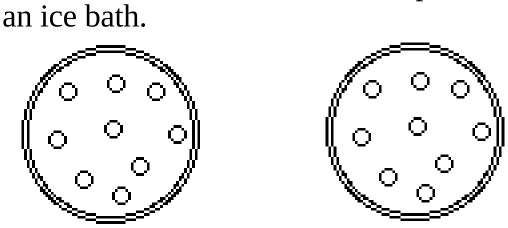
(10) 2. How many grams of carbon monoxide, CO, must be present in a 500.0 mL container at 21.0 ˚C and 1355 mm Hg?

$$PV = nRT$$
$$n = \frac{PV}{RT}$$
$$1355 \text{ mm Hg}\left(\frac{1 \text{ atm}}{760 \text{ mm Hg}}\right) = 1.78 \text{ atm}$$
$$n = \frac{1.78 \text{ atm} \cdot 0.500 \text{ L}}{(0.0821 \frac{\text{L·atm}}{\text{mol·K}})(294 \text{ K})} = 0.0369 \text{ mol}$$
$$0.\ 0369 \text{ mol}\left(\frac{28.0 \text{ g}}{1 \text{ mol}}\right) = 1.03 \text{ g CO}$$

(10) 3. Determine the molar mass of an unknown gas if 4.26 g occupies 2.36 L at 23.0 ˚C and 0.950 atm.

$$PV = nRT$$
$$n = \frac{mass}{\text{molar mass}}$$
$$PV = \frac{mass}{\text{molar mass}} \cdot RT$$
$$\text{Molar mass} = \text{mass} \cdot \frac{RT}{PV}$$
$$\text{Molar mass} = 4.26 \text{ g} \cdot \frac{0.0821 \frac{\text{L·atm}}{\text{mol·K}} \cdot 296\text{K}}{0.950 \text{ atm} \cdot 2.36 \text{ L}} = 46.2 \frac{\text{g}}{\text{mol}}$$

(4) 4. Consider the molecular-level (left) view of a sample of an ideal gas in a rigid steel sphere at 40 ˚C. Use the empty container on the right to draw another molecular-level picture of the sample of gas after the sphere is cooled to 10 ˚C using an ice bath.



The sample is still in the gas phase so the distribution of particles should look the same or very nearly the same as the original distribution.

(16) 5. Ammonium nitrate is most commonly used as a fertilizer or an explosive. When heated to 800 ˚C it acts as an explosive. The reaction which is generally accepted as occurring is;

$$2NH_4NO_3(s) \rightarrow 2N_2(g) + O_2(g) + 4H_2O(g)$$

a) Calculate the volume of nitrogen that will form when 1.00 pound of ammonium nitrate decomposes at 800 ˚C and 1.00 atm.

$$\mathbf{1.00\ lb\left(\frac{454\ g}{1\ lb}\right)\left(\frac{1\ mol\ NH_4NO_3}{80\ g}\right) = 5.68\ mol\ NH_4NO_3}$$

$$\mathbf{5.68\ mol\ NH_4NO_3\left(\frac{2\ mol\ N_2}{2\ mol\ NH_4NO_3}\right) = 5.68\ mol\ N_2}$$

$$\mathbf{PV = \mathit{n}RT}$$

$$\mathbf{V = \frac{\mathit{n}RT}{P}}$$

$$\mathbf{V = \frac{5.68\ mol \cdot 0.0821\frac{L{\cdot}atm}{mol{\cdot}K} \cdot 1073\ K}{1.00\ atm} = 500\ L}$$

b) If the decomposition products of 1.00 pound of ammonium nitrate were confined in a sealed 25.0 mL container at 800 ˚C, calculate the pressure exerted inside the container.

In part a we calculated the moles of N_2 formed. In this part it asks for the pressure exeerted by ALL the products so me need to determine the moles of O_2 and H_2O. To do that we use stoichiometry;

$$\mathbf{5.68\ mol\ N_2\left(\frac{1\ mol\ O_2}{2\ mol\ N_2}\right) = 2.84\ mol\ O_2}$$

$$\mathbf{5.68\ mol\ N_2\left(\frac{4\ mol\ H_2O}{2\ mol\ N_2}\right) = 11.36\ mol\ H_2O}$$

total moles of gas = 5.68 mol N_2 + 2.84 mol O_2 + 11.36 mol H_2O = 19.9 mole

$$\mathbf{PV = \mathit{n}RT}$$

$$\mathbf{P = \frac{\mathit{n}RT}{V}}$$

$$\mathbf{P = \frac{19.9\ mol \cdot 0.0821\frac{L{\cdot}atm}{mol{\cdot}K} \cdot 1073\ K}{0.025\ L} = 7.01 \times 10^4\ atm}$$

(9) 6. Indicate all the various types of intermolecular attractive forces that may operate in each of the following:

a) $CO(l)$; **dipole-dipole and London dispersion forces**

b) $CH_3Cl(l)$; **dipole-dipole and London dispersion forces**

c) $N_2(l)$; **London dispersion forces only**

(9) 7. Of the following molecules:

CH_3CH_2OH, CH_3OCH_3, CH_4, NH_3, F_2

a) Which can hydrogen bond to other molecules of the same kind?

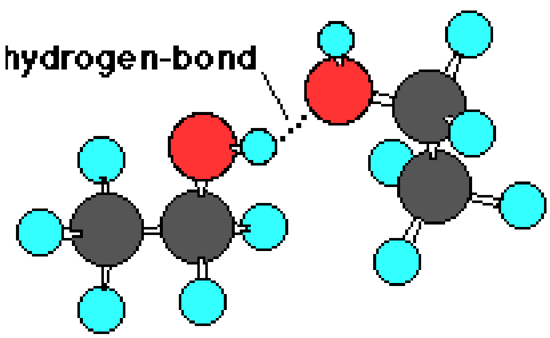
CH_3CH_2OH and NH_3

b) Which can accept hydrogen bonds from water?

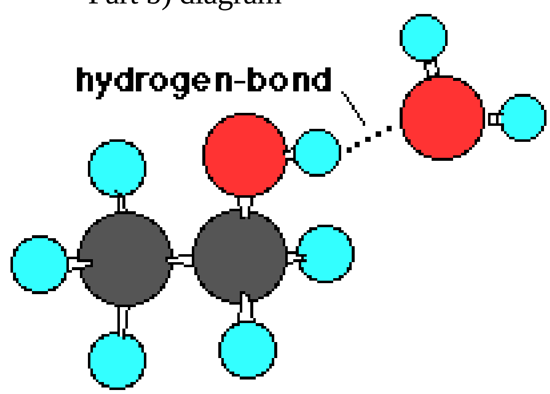
CH_3CH_2OH, CH_3OCH_3, NH_3

c) Using Lewis structures draw an example and label the hydrogen bond for one of the compounds you selected in part a) and one of the compounds you selected in part b)

Part a) diagram



Part b) diagram



(6) 8. The boiling point of HCl is higher than the boiling point of Ar. Briefly explain why.

HCl is polar compound so both dipole-dipole and London dispersion forces of attraction are acting in the liquid phase. Ar is a nonpolar atom and the only attractive forces are London dispersion. Since both have the same number of electrons the dispersion forces are approximately equal. Since HCl also as dipole-dipole forces it has the higher boiling point.

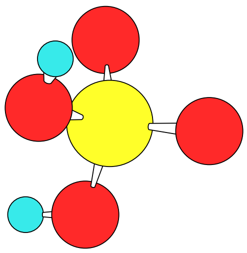
(8) 9. For pure substances the heat of vaporization is always greater than the heat of fusion. Briefly explain why.

The heat of vaporization is the heat required to boil a liquid converting the substances from the liquid phase to the vapor phase. The heat of fusion is the heat required to melt a substance converting the solid to the liquid. It takes more energy to convert the liquid to the vapor because ALL of the intermolecular attractive forces must be overcome to completely separate all the atoms/molecule from each other. When converting from solid to a liquid, only a few of the attractive forces between the atom/molecules must be overcome.

(8) 10. Which member of each of the following pairs is more soluble in water? Explain your answer.

a) H_2SO_4 or H_2S

H_2SO_4 is more soluble in water compared to H_2S. Looking at the structure of H_2SO_4 one notes the four oxygen atoms where hydrogen-bonding to water can occur. Additionally the –O-H in H_2SO_4 can also hydrogen-bond with water molecules. H_2S can not hydrogen-bond to itself and only has very weak hydrogen-bonding with water.



b) CH_2Cl_2 or CCl_4

CH_2Cl_2 is a polar compound while CCl_4 is a nonpolar compound. Polar compounds are more soluble in water than nonpolar compounds. Polar compounds have a small separation of charge on the molecule which allows interaction with another polar compound such as water.

(14)11a. Define the term equilibrium vapor pressure.

- **The pressure due to particles of a substance in the vapor phase above its liquid in a closed container at a given temperature.**

or

- **The maximum pressure exerted by the vapor above its liquid at a given temperature.**

or

- **The pressure exerted by the vapor above a liquid when the rate of evaporation is equal to the rate of condensation at a given temperature.**

b) What is the equilibrium vapor pressure of water at 75 ˚C?

289.1 mm Hg

c) At a given temperature is it possible to have a sample of water vapor in a closed container with a pressure higher than the equilibrium vapor pressure? Yes or No. Briefly explain.

No. The pressure due to the vapor above its liquid can never be greater than the equilibrium vapor pressure. By definition the equilibrium vapor pressure is the maximum pressure exerted by the vapor above its liquid at a given temperature.

d) At a given temperature is it possible to have a sample of water vapor in a closed container with a pressure lower than the equilibrium vapor pressure? Yes or No. Briefly explain.

Yes. If the pressure exerted by a sample of water vapor at a given temperature is less than the equilibrium vapor pressure that means there is no liquid present in the container. Additional sample can be added to increase the pressure to the equilibrium vapor pressure.

Periodic Table of the Elements

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII	VIII	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1	1 **H** 1.008																	2 **He** 4.00
2	3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
3	11 **Na** 22.99	12 **Mg** 24.30											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
4	19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
5	37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
6	55 **Cs** 132.9	56 **Ba** 137.3	57 **La** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.8	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
7	87 **Fr** (223)	88 **Ra** 226.0	89 **Ac** 227.0	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)									

Lanthanides	58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.2	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
Actinides	90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** 237.0	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

Useful Information

$PV = nRT$

$R = 0.0821 \frac{L \cdot atm}{mol \cdot K}$ $K = {}^{\circ}C + 273.15$ 1 pound = 454 g

1 atm = 760 mm Hg = 760 torr = 101,325 pascals (Pa)

Specific heat for water

Ice : $2.08 \frac{J}{g \cdot {}^{\circ}C}$

Water : $4.18 \frac{J}{g \cdot {}^{\circ}C}$

Water vapor : $1.84 \frac{J}{g \cdot {}^{\circ}C}$

Molar enthalpies of phase changes

Fusion : $6.01 \frac{kJ}{mol}$

Vaporization : $40.67 \frac{kJ}{mol}$

Solubility Table

Ion	Solubility	Exceptions
NO_3^-	soluble	none
ClO_4^-	soluble	none
Cl^-	soluble	except Ag^+, Hg_2^{2+}, *Pb^{2+}
SO_4^{2-}	soluble	except Ca^{2+}, Ba^{2+}, Sr^{2+}, Hg^{2+}, Pb^{2+}, Ag^+
CO_3^{2-}	insoluble	except Group IA and NH_4^+
PO_4^{3-}	insoluble	except Group IA and NH_4^+
CrO_4^{2-}	insoluble	except Group IA, IIA and NH_4^+
^-OH	insoluble	except Group IA, *Ca^{2+}, Ba^{2+}, Sr^{2+}
S^{2-}	insoluble	except Group IA, IIA and NH_4^+
Na^+	soluble	none
NH_4^+	soluble	none
K^+	soluble	none

*slightly soluble

Table of Equilibrium Vapor Pressures of Water

Temperature (°C)	Vapor Pressure(mmHg)	Temperature (°C)	Vapor Pressure(mmHg)
-5	3.2	50	92.5
0	4.6	55	118.0
5	6.52	60	149.4
10	9.20	65	187.5
15	12.8	70	233.7
20	17.5	75	289.1
25	23.8	80	355.1
30	31.8	85	433.6
35	42.1	90	525.8
40	55.3	95	633.9
45	71.9	100	760