Name KEY

Last 5 digits of Student Number: XXX – X ___ – ___ ___ ___ ___

Chem 116
Sample Examination #1

This exam consists of seven (7) pages, including this cover page. Be sure your copy is complete before beginning your work. If this test packet is defective, ask for another one.

A copy of the Periodic Table is attached at the back of the exam. You may remove it and use the back side of the Periodic Table as scratch paper. No work on scratch paper will be graded or collected.

The following information may be useful:

Constants of nature

$$R = 8.314\ \frac{J}{mol \bullet K} = 0.08206\ \frac{L \bullet atm}{mol \bullet K}$$

Conversions/Metric Prefixes
1 mol of an ideal gas at STP occupies 22.4 L
1 atm = 760 mmHg

Equations

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\frac{\text{rate of effusion of gas A}}{\text{rate of effusion of gas B}} = \sqrt{\frac{M_B}{M_A}}$$

DO NOT WRITE BELOW THIS LINE

Part I:

Questions 1-8	_____	(maximum 40)
Question 9	_____	(maximum 8)
Question 10	_____	(maximum 12)

Part II:

Question 1	_____	(maximum 20)
Question 2	_____	(maximum 20)
Extra credit	_____	(maximum 3)

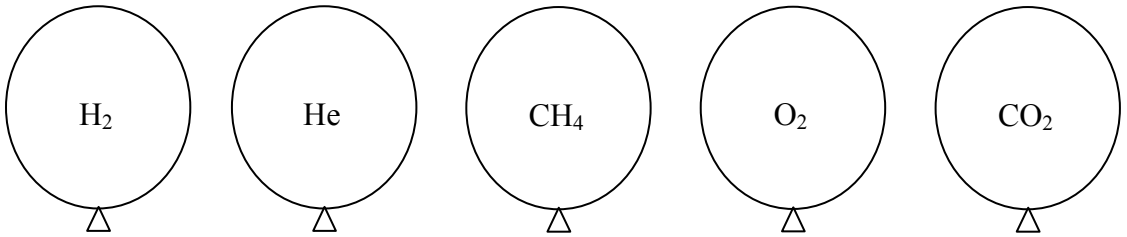
Total (out of 100) [ ]

Disclaimer:
This is a copy of a typical Exam 1 given in Chem 116 during the academic year. Your test will be different. This test is being posted to give you a sense of the format, style, scope and level of a typical test on this material. This test may have questions on topics that may not be covered on your exam. Moreover, your test may have questions on topics not covered in this practice exam. Posting this test in no way limits the format, style, scope and level of the test that you will take. Do not limit your preparation to the material in this practice exam.

Part I. Multiple-Choice or Short Response

There are 10 questions. Questions 1-8 are multiple-choice and are each worth 5 points. Question 9 looks like multiple-choice but there is more than one correct answer (you must indicate all correct answers on this question), and is worth 8 points. Question 10 requires a brief response and is worth 12 points.

C 1. The five balloons shown are at the same volume and temperature. Which of the following gases does hydrogen effuse four times faster than?



$\frac{r_{H_2}}{r_x} = 4 = \frac{M_x}{M_{H_2}}$ → $M_x = 16\ M_{H_2} = 32$

D 2. What type of intermolecular forces must be overcome to convert CCl_4 from a liquid to a gas?

A) ion-ion attractions
B) dipole-dipole attractions
C) hydrogen bonding
D) London dispersion forces
E) dipole – induced dipole attractions

↓
non polar molecule

A 3. A gas sample at 45 ºC and 0.80 atm occupies 3.20 L. At what temperature in degrees Celsius is the volume of the gas 1.80 L if the pressure is kept constant?

A) -94 ºC
B) -48 ºC
C) 25 ºC
D) 80. ºC
E) 290 ºC

$\frac{P_1 V_1}{P_2 V_2} = \frac{n_1 R T_1}{n_2 R T_2}$ n and P constant

↓

$\frac{V_1}{V_2} = \frac{T_1}{T_2}$ → $\frac{3.20\ L}{1.80\ L} \quad \frac{318\ K}{T_2}$ → $T_2 = 179\ K$

$= -94^\circ C$

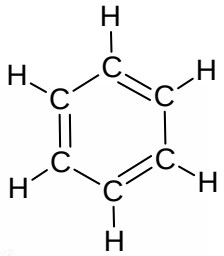
D 4. Which of the following aqueous solutions freezes at the lowest temperature? Assume ideal behavior.

A) 0.030 *m* sucrose ($C_{12}H_{22}O_{11}$)
B) 0.015 *m* NaCl
C) 0.012 *m* K_2CO_3
D) 0.010 *m* $(NH_4)_3PO_4$
E) 0.0010 *m* methanol (CH_3OH)

effective molality
0.030
0.030
0.036
0.040
0.0010

A

5. The vapor pressure of benzene (shown at right) is 79.8 mmHg in a flask at 20 ºC. What is the density of the vapor?



A) 0.341 g/L
B) 0.929 g/L
C) 3.14 g/L
D) 4.99 g/L
E) 28.0 g/L

$D = \frac{mass}{vol}$ and mass = moles × M_w

$D = \frac{n M_w}{V} = \left(\frac{P}{RT}\right) M_w = \frac{\left(\frac{79.8}{760}\right)(78)}{(0.0820)(293)}$ $M_w = 78$ g/mol

$= 0.341$ g/L

C

6. Equal numbers of moles of He (g), CO_2 (g) and N_2 (g) are placed in a single glass container at room temperature. The gases do not react with each other. If the container has a small pinhole leak, which of the following will be true after some of the gas mixture has effused?

A) $P_{N_2} < P_{CO_2} < P_{He}$
B) $P_{CO_2} < P_{He} < P_{N_2}$
C) $P_{He} < P_{N_2} < P_{CO_2}$
D) $P_{He} < P_{CO_2} < P_{N_2}$
E) $P_{He} = P_{N_2} = P_{CO_2}$

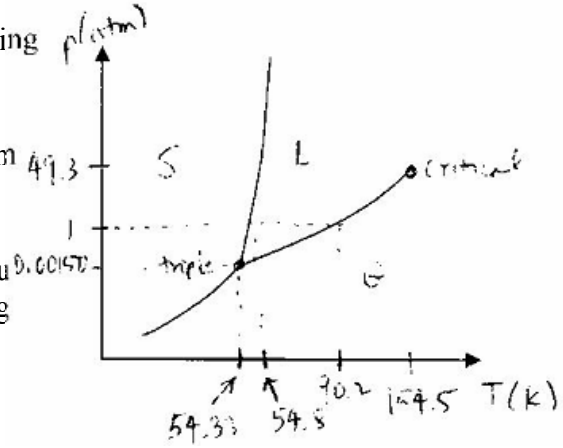
He has smallest mass → fastest → escapes most → P_{He} lowest

CO_2 has largest mass → slowest → escapes least → P_{CO_2} highest

B

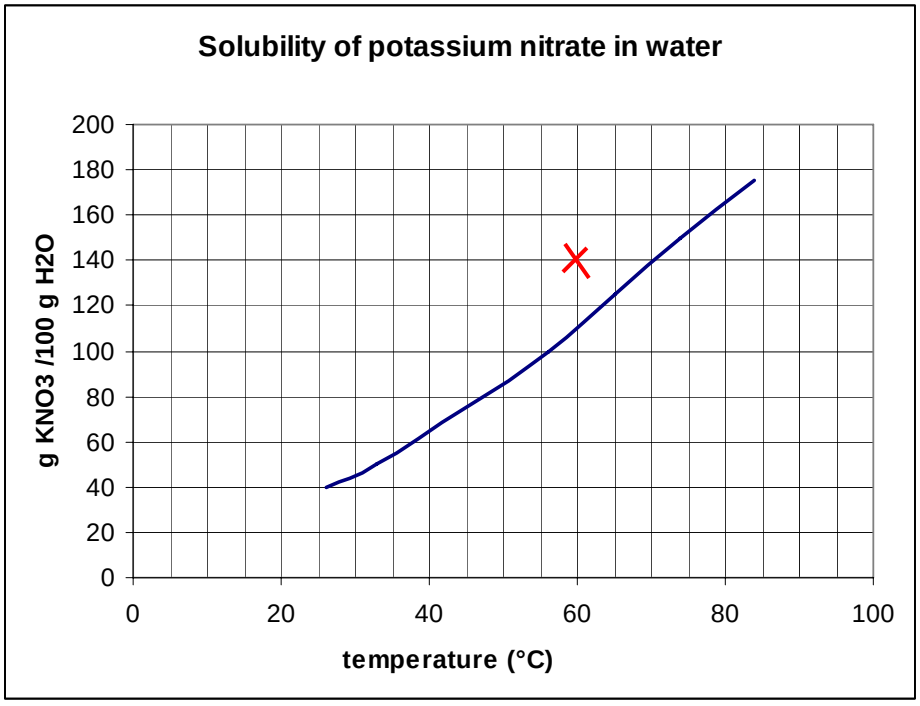
7. The phase diagram of oxygen (O_2) includes the following points:

- Critical point: $T_c = 154.5$ K, $P_c = 49.3$ atm
- Triple point: $T_{t.p.} = 54.33$ K, $P_{t.p.} = 0.00150$ atm
- Normal melting point: $T_{fus} = 54.8$ K
- Normal boiling point: $T_{vap} = 90.2$ K



You may wish to use the sketch at the right to help you answer the question. Under which one of the following conditions is oxygen a liquid?

A) $T = 50.$ K, $P = 0.80$ atm
B) $T = 60.$ K, $P = 0.50$ atm
C) $T = 90.$ K, $P = 0.20$ atm
D) $T = 100.$ K, $P = 0.050$ atm
E) $T = 150.$ K, $P = 1.0$ atm



C

8. The chart above shows the solubility of potassium nitrate (KNO_3) in water. You are given a 7.93-molal KNO_3 solution in the laboratory at 60 ºC. What is true about this solution?
   A) It is below saturation
   B) It is exactly at saturation
   C) It is supersaturated
   D) There is not enough information to tell

$$13.9\ \text{molal} = \frac{13.9\ \text{mol}\ KNO_3}{1000\ \text{g}\ H_2O} = \frac{1.39\ \text{mol}\ KNO_3 \times \frac{101.1\ \text{g}}{\text{mol}}}{100\ \text{g}\ H_2O} = \frac{141\ \text{g}\ K}{100\ \text{g}\ H}$$

9. Compare 1.00 mol of pure carbon dioxide (CO_2) in the gas state with 1.00 mol of CO_2 in a condensed phase (liquid). Indicate all statements below that are true (this is not multiple-choice, there is more than one correct answer to indicate).

___ The gas particles have less kinetic energy on average than particles in the condensed phase.

☺ The gas particles are very far apart from each other compared to particles in the condensed phase.

☺ The gas occupies all space available to it while the condensed phase occupies a specific volume.

___ The gas is more dense than the condensed phase.

☺ The gas is much more compressible than the condensed phase.

10. Identify which of the following gases deviates most from ideal behavior and provide a brief explanation of why. Make sure to identify which assumption or assumptions break down. (Note: geometry of SO_2 molecule is bent, geometry of CH_4 molecule is tetrahedral.)

(SO_2) Ne CH_4 N_2 H_2

Any one of:

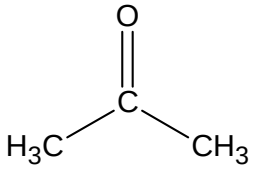
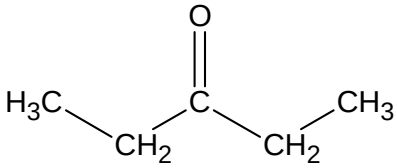
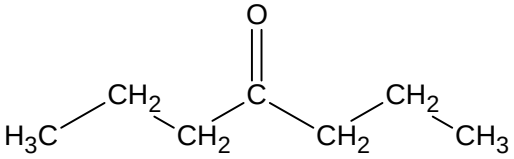
- SO_2 is a polar molecule and all the others are small molecules and are nonpolar. So attractions between SO_2 molecules are dipole-dipole and are stronger than any attraction in the others. The assumption that there are no attractive forces breaks down. (Collisions not as elastic)
- SO_2 is a larger molecule than any of the others, so it takes up more space. The assumption that the space taken up by the molecules is negligible compared to the space they occupy is not as good.
- SO_2 is the largest molecule so it has the strongest London forces. The assumption that there are no attractive forces breaks down. (Collisions not as elastic)

Part II. Problems

Each problem is worth 20 points.

1. In the table below is shown a series of ketones, their molecular structures, and their boiling points. Provide an explanation for the following trend.

As the number of carbons in the ketones increases, the boiling points increase.

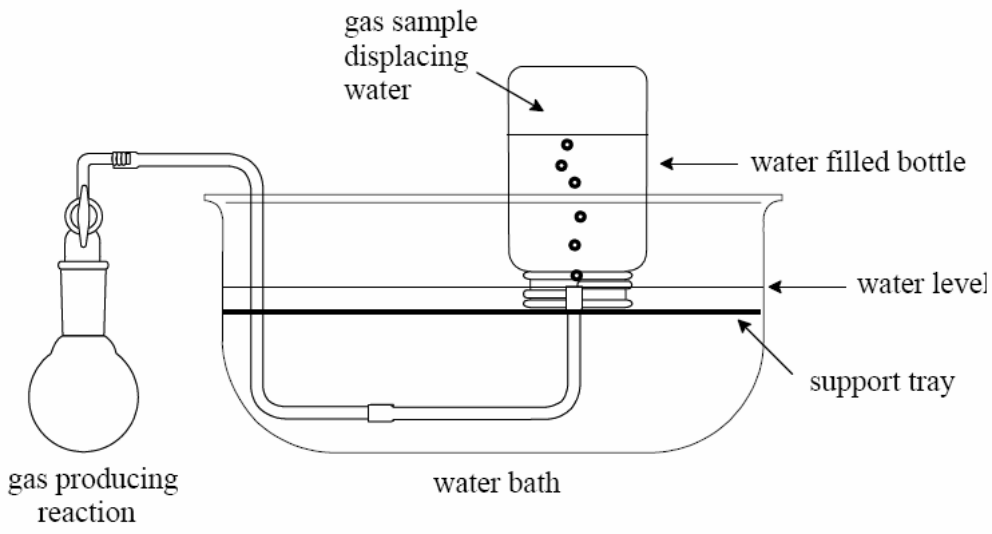
Name of compound	Molecular structure	Boiling point (ºC)
dimethyl ketone (acetone)		56.3
diethyl ketone (3-pentatone)		102.1
dipropyl ketone (4-heptanone)		144.0

1. All these molecules have the same polar bond (C=O). Therefore they all have similar dipole moments and the dipole-dipole attractions are similar.

2. All these molecules have different molecular sizes (molecular weight and length increase as # of carbons increases). London dispersion forces increase as molecular size increases.

3. As the London forces become stronger, you have to take the substance to a higher temperature to give the molecules enough kinetic energy to overcome the attractive forces that hold them near other molecules in the liquid state. Thus, the boiling point increases as the London forces increase

2. The apparatus shown here is used to collect carbon dioxide (CO_2) gas over water.



Calcium carbonate ($CaCO_3$, molar mass 100.1 g/mol) is heated in the flask, and decomposes to form CO_2 gas according to the following reaction:

$$CaCO_3\,(s) \rightarrow CaO\,(s) + CO_2\,(g)$$

On this day in the laboratory, atmospheric pressure is 758 torr. The water temperature is 27ºC, and the vapor pressure of water at this temperature is 26.7 torr. If the total volume of gas collected is 143 mL, and if all of the $CaCO_3$ reacted, what original mass of $CaCO_3$ must have been present?

$P_{total} = P_{H_2O} + P_{CO_2} \rightarrow P_{CO_2} = 758 - 26.7\ torr = 731.3\ torr$

$PV = nRT \rightarrow n_{CO_2} = \dfrac{P_{CO_2}V}{RT} = \dfrac{\left(\frac{731.3}{760}\right)(0.143)}{(0.08206)(300)} = 0.005589\ mol\ CO_2$

Same # moles $CaCO_3$ (stoichiometry is 1:1)

$0.005589\ mol\ CaCO_3 \times \dfrac{100.1\ g}{mol} = \boxed{0.559\ g}$

Extra credit (up to 3 points):

Provide one reason why the total volume of gas actually collected is less than theoretically possible.

Some of the CO_2 dissolves in the liquid water.

or

Some of the CO_2 reacts with the liquid water (to make H_2CO_3 or HCO_3^-)