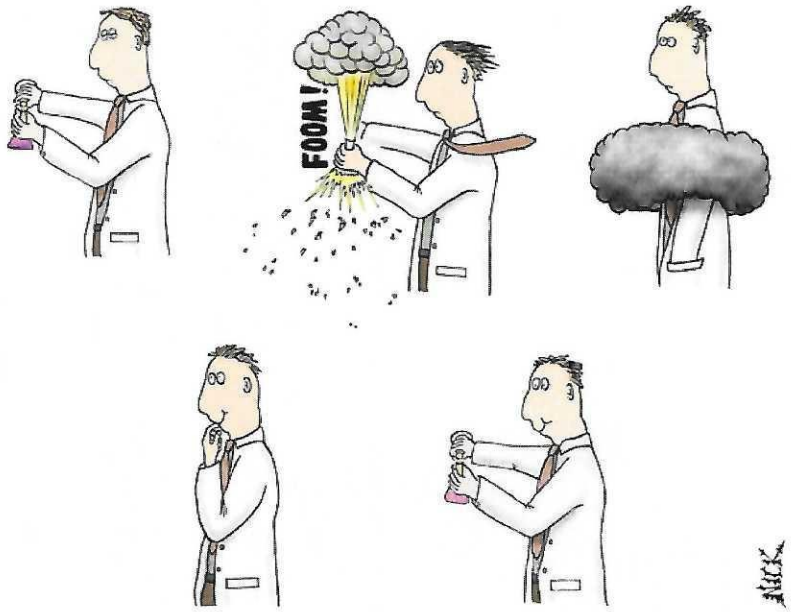
Name KEY

Chemistry 121
Test 2
Spring 2021

Page	Score
2.	/16
3.	/11
4.	/11
5.	/15
6.	/16
7.	/15
8.	/16
9.	/
10.	/EC
11.	/EC
Total	/100



Read this first: Don't panic. **This is a strictly timed exam. You must work quickly and accurately.** You have 54 minutes to complete the exam. If the space provided is insufficient for showing your work, continue on the back of the page. Don't forget to indicate where the work may be found. If there are questions ask the instructor not your neighbor. You may not share calculators. **Have fun.**

☐ Check here if you would like your approximate current course grade
This grade includes all exams, quizzes and homework scores to this point in the semester. It should be used only as a guide to help you determine your progress in the course and is subject to change depending upon further scores on exams, homework, and quizzes. Your grade will be in the lower right of the next page.

I. Descriptive: If no correct answer is given in a multiple choice question, write in the correct answer. Use only the space provided for essay/short answer questions. Brevity will be rewarded and the free point is for a small happy face in the lower right corner of the next page. Incorrect answers, even accompanied by correct answers, will receive a penalty.

1. (4 pts.) Which of the following factors affect the quantity of a nonvolatile solute that will dissolve in a solvent? Check all that apply.

   - ■ volume of the solvent
   - ☐ volume of the vapor above the solvent
   - ☐ intermolecular forces between the solvent molecules
   - ■ intermolecular forces between the solute molecules
   - ■ intermolecular forces between the solvent and solute molecules
   - ☐ the volume of the container holding the solvent
   - ☐ temperature of the solvent

2. (6 pts.) Arrange the following compounds in predicted order of increasing boiling point.

   CH_3OH **C_3H_6** **NaCl** **H_2O** **CuO** **CH_3-CH_3**

   CH_3CH_3 — lowest b.p.

   C_3H_6

   CH_3OH

   H_2O

   NaCl

   CuO — highest b.p.

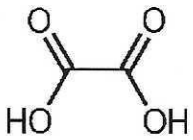
3. (6 pts) A saturated solution of bromine (Br_2) in water is very dilute; that is, Br_2 is not very soluble in water. When dichloromethane (CH_2Cl_2) is mixed with Br_2-water and shaken, the water and dichloromethane separate. The density of dichloromethane is 1.33 g/mL.

   A 100 mL volume of a dilute aqueous solution of bromine is mixed with 100 mL of dichloromethane in an Erlenmeyer flask, stoppered, and shaken vigorously. After the mixture is left stoppered and allowed to sit for a few moments…

   a. …the mixture will
      - ■ separate into two layers with the water on top.
      - ☐ separate into two layers with the dichloromethane on top.
      - ☐ remain mixed as a completely homogeneous solution.

   b. …most or all of the bromine will
      - ☐ remain in the aqueous phase.
      - ■ move into the dichloromethane phase.
      - ☐ become equally and homogeneously distributed between the water and dichloromethane.
      - ☐ ionize.
      - ☐ evaporate.

4. (5 pts.) For the following compounds, check each box that applies for the intermolecular forces exhibited by that compound with others of the same molecule (cohesive forces).

	Hydrogen bonding	Dipole-dipole	London Dispersion Forces
 1-octanol	☒	☒	☒
$H_3C\text{-}CCl_3$ 1,1,1-trichloroethane	☐	☒	☒
SO_2	☐	☒	☒
N_2	☐	☐	☒
 oxalic acid	☒	☒	☒

5. (3 pts.) Ammonia (NH_3) very soluble in water but benzene is almost insoluble in water. In only the space provided in the box, explain this observation from the point of view of intermolecular forces. Any hint of "like-dissolves-like" will result in a severe penalty. Illegible writing and text outside the box will be ignored.

Ammonia can form a strong hydrogen bond with water that's promotes solubility. Benzene being nonpolar can only interact w/ammonia through the LDF. The ammonia is so small it exhibits a very small LDF w. the benzene - so small it can't overcome the H-bond

6. (3 pts.) The concentration of a gas in a liquid solvent _____ with _____ partial pressure.

- ☐ decreases, increasing
- ☒ increases, increasing
- ☐ increases, decreasing
- ☐ remains unaffected, changing
- ☐ huh?

7. (4 pts.) Without doing any detailed calculations, arrange the following aqueous solutions in order of increasing (lowest to highest) freezing points.

0.100 m ethanol (CH_3CH_2OH) 0.150 m $Mg(NO_3)_2$ 0.110 m NaCl 0.190 m sucrose ($C_{12}H_{22}O_{11}$)

lowest f.p.						highest f.p.
■	0.150 m $Mg(NO_3)_2$	< 0.110 m NaCl	< 0.190 m sucrose	<	0.100 m ethanol	
☐	0.150 m $Mg(NO_3)_2$	< 0.190 m sucrose	< 0.110 m NaCl	<	0.100 m ethanol	
☐	0.100 m ethanol	< 0.190 m sucrose	< 0.110 m NaCl	<	0.150 m $Mg(NO_3)_2$	
☐	0.100 m ethanol	< 0.110 m NaCl	< 0.190 m sucrose	<	0.150 m $Mg(NO_3)_2$	
☐	0.110 m NaCl	< 0.100 m ethanol	< 0.190 m sucrose	<	0.150 m $Mg(NO_3)_2$	
☐	0.110 m NaCl	< 0.100 m ethanol	< 0.150 m $Mg(NO_3)_2$	<	0.190 m sucrose	

☐ None of these are correct. The correct order is:

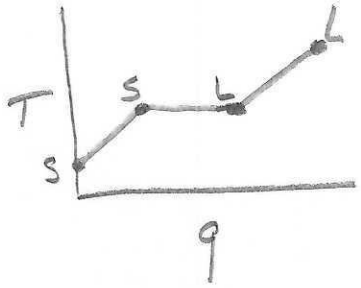
---

8. (7 pts.) Consider a stoppered Erlenmeyer flask containing a saturated aqueous solution of potassium chloride with a small quantity of solid potassium chloride laying at the bottom of the solution. What effect would be predicted for each of the following changes to the solution?

	decrease	remain unchanged	increase
Removal of one-half of the undissolved potassium chloride from the flask will cause the vapor pressure the solution to	☐	■	☐
After the addition of water (but an insufficient amount to dissolve all of the remaining solid), followed by allowing the solution to reestablish saturation, the vapor pressure of the solution will	☐	■	☐
Evaporating the solution to one-half its original volume will cause the vapor pressure of the solution to	☐	■	☐
After the addition of more potassium chloride the vapor pressure of the solution will	☐	■	☐
Vigorous stirring of the solution will cause the vapor pressure of the solution to	☐	■	☐
After pouring the entire contents of the Erlenmeyer flask into another flask of twice the volume and stoppering the flask, the new vapor pressure, compared to the original, will	☐	■	☐
After addition of sufficient water to dissolve all of the undissolved potassium chloride, and then a little more water, the vapor pressure will	☐	☐	■

II. Problems: Neatness and a logical approach count for as much as 25% of the partial credit. Illegible work will be ignored. Units are required for full credit.

1. (15 pts.) Foundries require enormous amounts of energy to melt metals in preparation for forging and casting the metals for use in applications like building support structures or eating utensils. Calculate the amount of energy necessary to heat 1.0 kg of solid iron from 22°C to molten (liquid) iron at 2250°C.



Some Important Properties of Iron
$\Delta H_{fusion} = 13.80$ kJ/mol
$\Delta H_{vap} = 340$ kJ/mol
Specific heat Fe(s) = 0.450 J/g·°C
Specific heat Fe(l) = 0.521 J/g·°C
Specific heat Fe(g) = 0.199 J/g·°C
density of Fe = 7.86 g/cm^3
melting point = 1538 °C
boiling point = 2861 °C

$q_{TOTAL} = q_{s\to s} + q_{s\to L} + q_{heating\ L}$

$= mc\Delta T + n\Delta H + mc\Delta T$

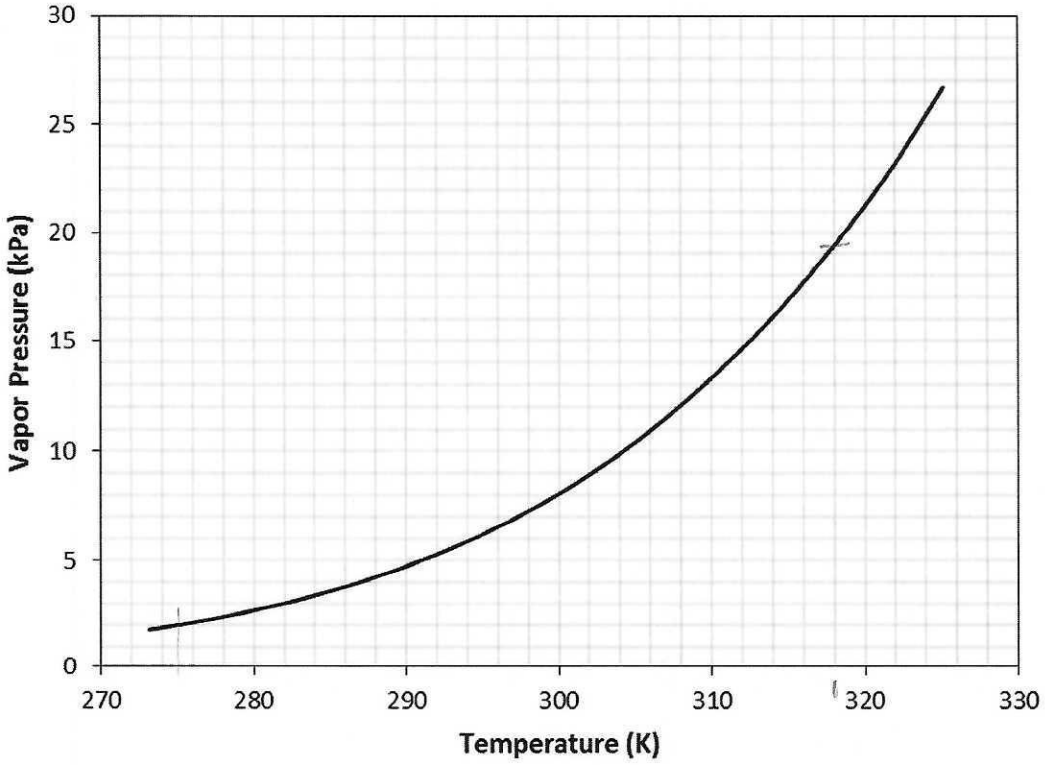
$= (1000_g)(0.450\ J/_{g°C})(1538°C - 22°C) + \left(1000_g / 55.847_{g/mol}\right)(13.80\times10^3\ J/_{mol})$

$+ (1000_g)(0.521\ J/_{g°C})(2250°C - 1538°C)$

$= 1.36\times10^6\ J = 1.30\times10^3\ kJ$

2. (16 pts.) Ethanol is the product in the yeast fermentation of carbohydrates and is used as an additive to gasoline to improve combustion. It can be consumed in small amounts, often resulting in humorous side effects. One danger of ethanol is its relatively high vapor pressure and nearly invisible flame when burning, making it a potentially dangerous fuel.

   The graph gives the vapor pressure of ethanol at different temperatures, as measured in lecture. Calculate the normal boiling point of ethanol. Show your work and present your answer in degrees Celsius. Place your answer in the provided box.



Show your work:

$T_1 = 275\,K \quad P_1 = 2.0\,kPa$

$T_2 = 318\,K \quad P_2 = 15.5\,kPa$

$$\ln\frac{2.0\,kPa}{15.5\,kPa} = \frac{\Delta H_{vap}}{8.314\,J/mol\,K}\left(\frac{1}{318\,K} - \frac{1}{275\,K}\right)$$

$E_a = 34{,}623\,J/mol$

$$\ln\frac{101.325\,kPa}{15.5\,kPa} = \frac{34{,}623\,J/mol}{8.314\,J/mol\,K}\left(\frac{1}{318\,K} - \frac{1}{T_{nbp}}\right)$$

$$\frac{1}{T_{nbp}} = 2.694\times10^{-3}\,K^{-1} \qquad T_{nbp} = 371\,K$$

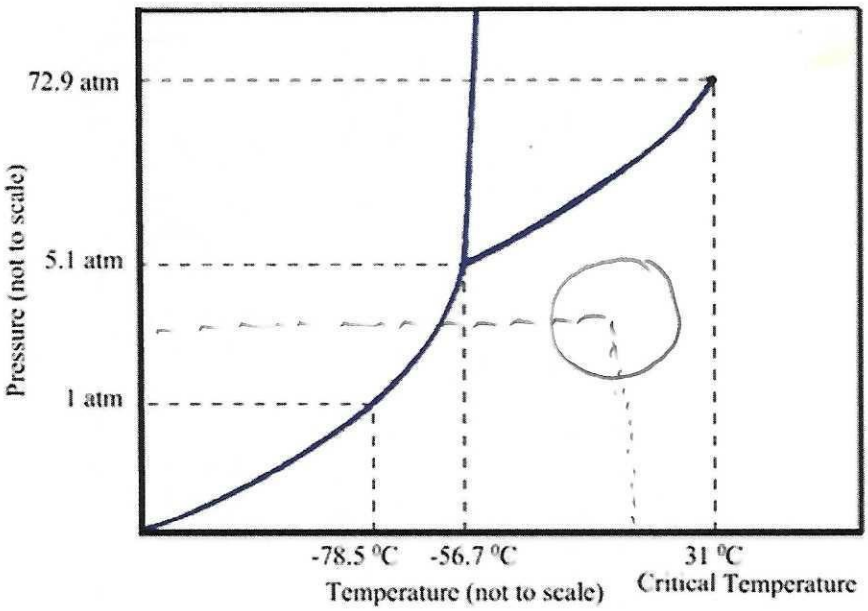
$T_{nbp} = 371\,K - 273.2$

$= 98\,^{\circ}C$

n.b.p. = 98 °C

3. (15 pts.) A 6.78 g sample of dry ice, $CO_2(s)$, was allowed to sublime in a 1.5 L sealed stainless steel container thermostatted at 27.0°C. Which answer correctly reflects the contents of the flask? You may find the phase diagram at the right helpful. A correct answer without supporting work receives zero credit.

- ☐ Solid only
- ☐ Liquid only
- ☒ Gas only
- ☐ A mixture of solid and liquid
- ☐ A mixture of solid and gas
- ☐ A mixture of liquid and gas



Supporting work:

$n = 6.78\,g / 44.01\,g/mol = 0.154\,mol$

$T = 273.2 + 27.0\,°C = 300.2\,K$

$P = \frac{nRT}{V} = \frac{(0.154\,mol)(0.08206\,\frac{L\,atm}{mol\,K})(300.2\,K)}{1.5\,L}$

$= 2.53\,atm$

at this T & P, CO_2 is all gas

Do problem only 4 *or* 5. Problem 5 has a small amount of extra credit as a part of the problem. If you attempt both, indicate which problem you want graded for credit by circling the problem number. If no indication is made, problem 4 will be graded and scored.

4. (16 pts.) Ethyl oleate is a molecular pheromone released by honey bees to maintain the best balance of forager to nurse bees in the hive. A solution containing 26.3 mg of the compound in 0.450 g of benzene freezes at 4.54°C. What is the molar mass of the pheromone?

$\Delta T = -iK_f C$

$4.54°C - 5.50°C = -(1)(5.12°C/m)\left(\frac{n}{4.5\times10^{-4}\,kg}\right)$

$n = 8.438\times10^{-5}\ mol$

$M = \frac{0.0263\,g}{8.438\times10^{-5}\,mol} = 312\,g/mol$

Selected Thermodyanmic Data for Benzene

ΔH_{fusion}	9.95 kJ/mol
ΔH_{vap}	33.9 kJ/mol
$K_{f,benzene}$	5.12°C/*m*
$K_{b,benzene}$	2.53°C/*m*
Specific heat (l)	1.73 J/g°C
Specific heat (g)	1.06 J/g°C
Normal freezing point	5.50°C
Normal boiling point	80.1°C

4a. **Extra Credit (3 pts):** Elemental analysis showed that the pheromone contains only carbon, hydrogen and oxygen with a percentage composition of 77.36%C and 12.33%H. What is its molecular formula?