CHEMISTRY 112, Section 1
Exam #1

NAME: **ANSWER KEY**
February 19, 2020

Q1. A series of short answer questions. (2 pts each)

Boiling Points: SO_2 = -10 °C SO_3 = 44.9 °C

a) SO_3 has stronger IMFs that does SO_2. **true** or false

b) The melting point of SO_2 is likely greater than that of SO_3. true or **false**

c) The enthalpy of vaporization of SO_2 is likely greater than that of SO_3. true or **false**

d) The surface tension of SO_2 is likely greater than that of SO_3. true or **false**

e) The vapor pressure of $SO_2(l)$ is likely greater than that of $SO_3(l)$. **true** or false

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f) It is possible for one non-polar compound to have stronger IMFs than a different compound that has hydrogen bonding. **true** or false

g) If the partial pressure of water vapor in the air is less than water's vapor pressure at that temperature, fog can form. true or **false**

h) The vapor pressure of all liquids rise as temperature rises. **true** or false

i) IMF strength is the primary factor determining a liquid's viscosity. true or **false**

j) Surface tension is the only factor determining how spherical a drop is. true or **false**

k) For dispersion forces, as molecular size increases, IMF force increases. **true** or false

l) For ionic compounds, as ion size increases, ionic bond strength increases. true or **false**

m) A supercritical fluid is a liquid. true or **false**

n) Compounds and elements can have different solid phases. Can they also have different liquid phases? yes or **no**

o) Enthalpy change (favors or **disfavors**) evaporation of a liquid.

p) Entropy change (**favors** or disfavors) evaporation of a liquid.

Q2. Consider the following ionic compounds: KBr, $MgCl_2$, $MgBr_2$
(6 pts)

a) which has the lowest melting point: **KBr (lowest charges)**

b) which has the highest melting point: **$MgCl_2$ (high charges and smaller ion sizes)**

38

130 pts total

Q3. a. Which of the following forces are responsible for holding CH_3Cl in the liquid state? Circle all that apply. (9 pts)

Dipole-dipole H-bonding **Induced dipole-Induced dipole** C-H Covalent Bonds

b. Which of the following forces are responsible for holding CH_3OH in the liquid state? Circle all that apply.

Dipole-dipole **H-bonding** **Induced dipole-Induced dipole** C-H Covalent Bonds

c. Which of the following forces are responsible for holding CCl_4 in the liquid state? Circle all that apply.

Dipole-dipole H-bonding **Induced dipole-Induced dipole** C-H Covalent Bonds

Q4. Consider these molecules: **A:** $CH_3CH_2NH_2$ **B:** CH_3CH_2F **C:** $CH_3CH_2CH_3$ **D:** CH_3CH_3 (8 pts)

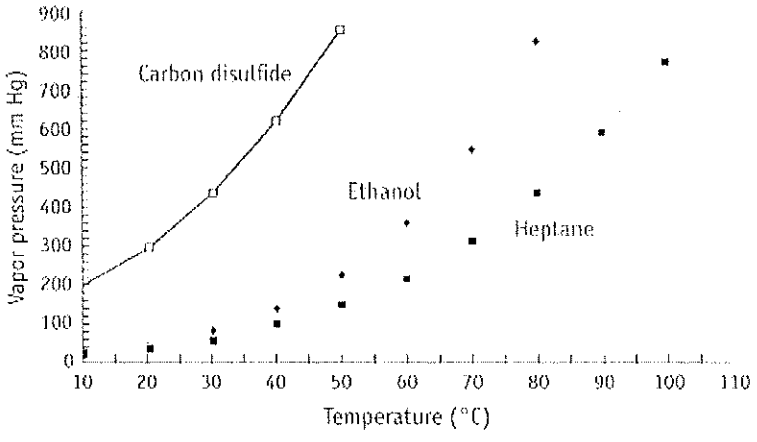
a. Which has the strongest IMFs: ***enter letter*** A (hydrogen bonding due to $-NH_2$ group)

b. Which will have the highest vapor pressure: D (monpolar and small size)

c. Which will have the highest boiling point: A

d. Which will have the highest enthalpy of vaporization: A

Q5. Use the vapor pressure curves to answer the following. (8 pts) Give the:



a. Vapor pressure of ethanol at 70 °C.

550 mmHg

b. The normal boiling point of carbon disulfide.

47 °C

c. Which of the three has the weakest intermolecular forces?

Carbon disulfide (highest vapor pressure)

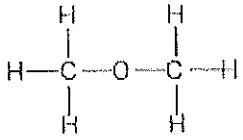
d. Which compound has the largest enthalpy of vaporization?

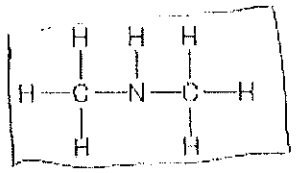
Heptane (lowest vapor pressure = strongest IMFs)

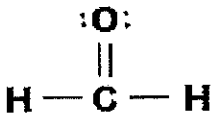
Q6. What is the energetic driving force for the reaction of metallic potassium and elemental Br_2 to form solid potassium bromide?
(5 pts)

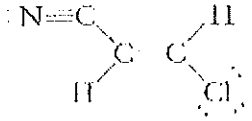
Lattice energy for bringing K^+ and Br^- ions together into the ionic solid.

Q7. For which of the following compounds would hydrogen bonding be expected to play an important role in holding the molecules in the liquid state. Circle all that apply. (5 pts)







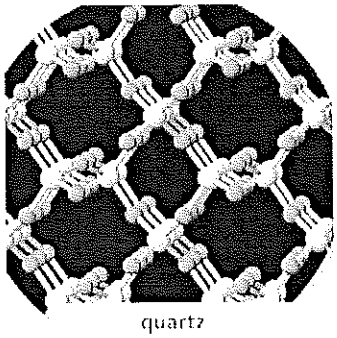


Q8. What type of solid is each of the following: (choices: molecular, ionic, extended/covalent, metallic)
(5 pts)

quartz **extended covalent**

ice **molecular**

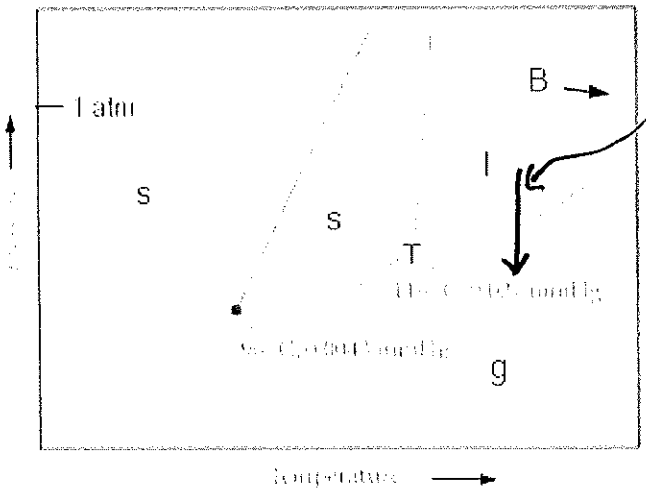
potassium nitrate **ionic**


quartz

Which of the above will have the weakest IMFs? **ice**

Q9. Consider the phase diagram below for an element.
(5 pts)

This element has two different solid phases.



a. Label each of the four regions as gas, liquid or solid.

b. Draw an arrow for the transition that occurs when the liquid evaporates at constant temperature.

c. Write a "T" on top of the triple point.

d. Write a "B" showing the normal boiling point.

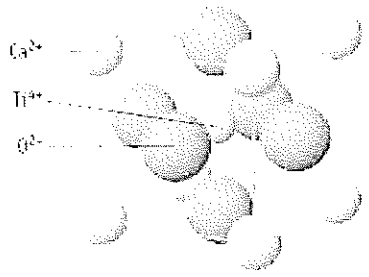
e. Is the liquid more or **less** dense than the solid?

Less dense

28

LONG ANSWER QUESTIONS: ALL WORK MUST BE SHOWN

Q10. Using the unit cell structure shown here, determine the formula of the unit cell of this compound. The Ti ion is in the very center of the unit cell. (6 pts)



Ca: 8 corners x 1/8 each = 1 Ca
Ti: 1 inside = 1 Ti
O: 6 faces x ½ each = 3 O

Formula: $CaTiO_3$

Q11. a) The vapor pressure of propane at -1 °C is 3.52 atm. and at 27 °C is 8.74 atm. Use this to determine the enthalpy of vaporization of propane. (10 pts)

$P_1 = 3.52 atm \; T_1 = 272K$

$P_2 = 8.74 atm \; T_2 = 300K$

propane = $CH_3CH_2CH_3$

$$\ln \frac{8.74}{3.52} = + \frac{\Delta H_{vap}}{R}\left[\frac{1}{272} - \frac{1}{300}\right]$$

$$0.9094 = + \frac{\Delta H_{vap}}{8.314 J/K \cdot mol}\left[3.431 \times 10^{-4} K^{-1}\right]$$

$$\Delta H_{vap} = \frac{0.9094 \times 8.314 J/K \cdot mol}{3.431 \times 10^{-4} K^{-1}}$$

$$= 22{,}034 J/mol$$

22.0 kJ/mol

Why is propane stored in a heavy steel container but butane ($CH_3CH_2CH_2CH_3$) stored in a much weaker plastic container.

Propane and butane are both nonpolar hydrocarbons. Propane is smaller and therefore has weaker dispersion forces. This leads to higher vapor pressure for propane and the need for a stronger container.

Q12. An aqueous solution of nitric acid (HNO_3) is 36% by weight HNO_3 and has a density of 1.19 g/mL. (9 pts)
Calculate the following:

mole fraction HNO_3: $\chi(HNO3) = \frac{\text{mol } HNO_3}{\text{mol } HNO_3 + \text{mol } H_2O} = \frac{0.571 mol}{0.571 mol + 3.55 mol} = 0.139$

molality:

$molality(HNO_3) = \frac{\text{mol } HNO_3}{kg\ H_2O} = \frac{0.571 mol\ HNO_3}{0.064 kg\ H_2O} = 8.92 m$

Assume 100 g solution.

$36.0 g\ HNO_3 \times \frac{1 \text{ mol } HNO_3}{63.01 g\ HNO_3} = 0.571 \text{ mol}$

$64.0 g\ H_2O \times \frac{1 \text{ mol } H_2O}{18.02 g\ H_2O} = 3.55 \text{ mol } H_2O$

molarity:

Volume of 100 g solution:

$100 g \times \frac{1 mL}{1.19 g} \times \frac{1 L}{1000 mL} = 0.0840 L$

$molarity(HNO_3) = \frac{\text{mol } HNO_3}{\text{L solution}} = \frac{0.571 mol\ HNO_3}{0.0840 \text{ L}} = 6.80 M$

Q13. Consider four solutions:
(~~8 pts~~) 10

0.23 m NaOH **0.46 m ions**

0.18 m KBr **0.36 m ions (lowest concentration)**

0.13 m $Zn(NO_3)_2$ **0.39 m ions**

0.42 m sucrose (nonelectrolyte) **0.42 m molecules (highest concentration)**

Which compound has the highest boiling point? ~~0.42 m sucrose~~ NaOH or can't tell NaOH

Which compound has the highest freezing point? **0.18 m KBr** or can't tell KBr

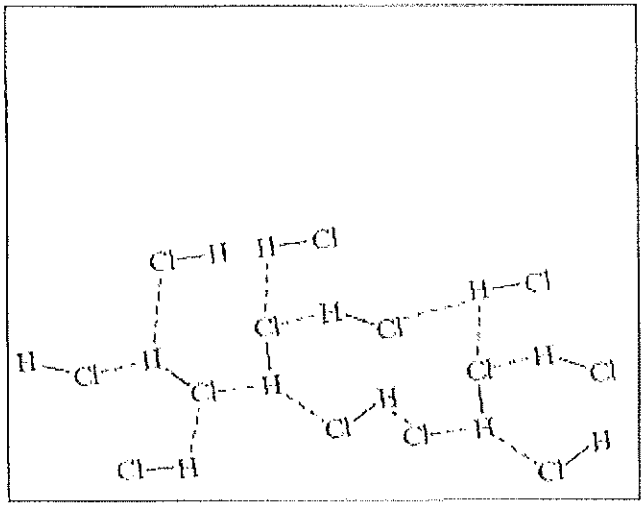
Which compound has the highest vapor pressure? **0.18 m KBr** or can't tell ~~NaOH~~ KBr

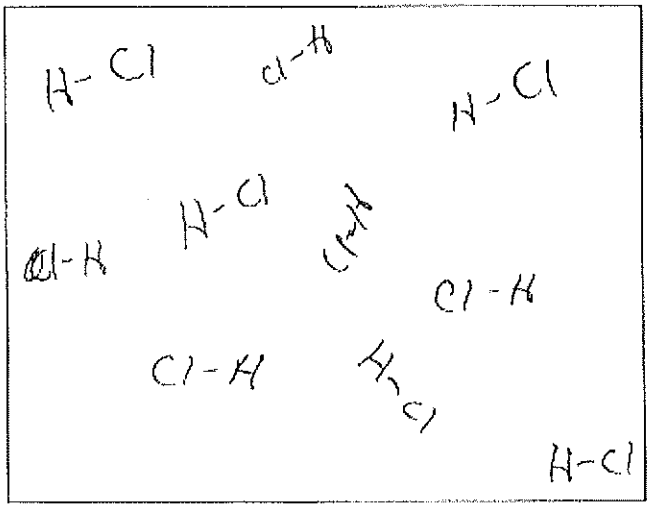
Which compound has the highest osmotic pressure? ~~0.42 m sucrose~~ NaOH or can't tell NaOH

Which compound has the highest viscosity? _____ or **can't tell**

100
19

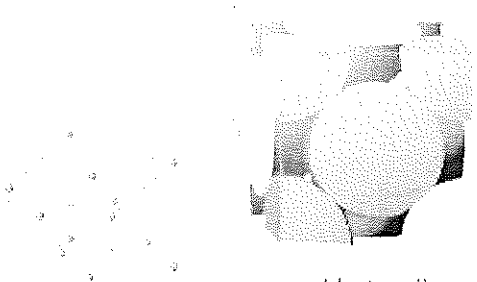
Q14. The box on the left has a depiction of HCl in the liquid phase. Draw in the right box a depiction of the same atoms/molecules after they vaporize. (4 pts)





Q15. Metallic **gold** crystallizes in a **face-centered** cubic lattice, with one **Au** atom per lattice point. How many atoms are inside each unit cell?
(8 pts)

4



If the edge length of the unit cell is found to be **408** pm, what is the metallic radius of **Au** in pm?

The diagonal has a length equal to 4 times the atomic radius.

Diagonal = $408\,pm \times \sqrt{2} = 577\,pm$

$$radius(Au) = \frac{577\,pm}{4} = 144\,pm$$