CHEMISTRY 112, Section 1
Exam #1

NAME: Answer Key
February 12, 2018

Q1. Which of the following forces are responsible for holding CH_3Cl in the liquid state? Circle all that apply.

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Ion-ion Ion-dipole Dipole-dipole

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

Q2. Consider these molecules: **A:** $CH_3CH_2NH_2$ **B:** CH_3CH_2F **C:** $CH_3CH_2CH_3$ **D:** CH_3CH_3

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a. Which has the strongest IMFs: ***enter letter*** A

b. Which will have the highest vapor pressure: D

c. Which will have the highest boiling point: A

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

Q3. Use the vapor pressure curves to answer the following questions.

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a. What is the vapor pressure of ethanol when the temperature is 70 °C.

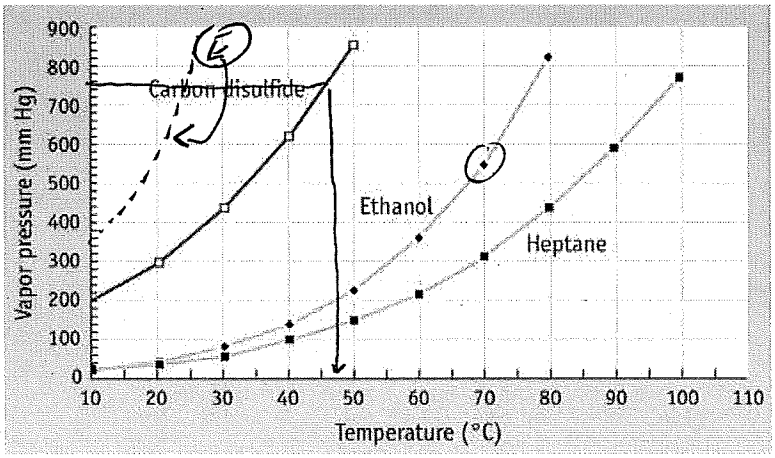
550 mmHg

b. What is 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 = highest ΔH_{vap})

e. Draw a new curve on the graph for a compound with weaker intermolecular forces than the compounds depicted.

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Q4. A series of short answer questions:

SO_2 has a boiling point of -10 °C. SO_3 has a boiling point of 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 ~~melting point~~ surface tension of SO_2 is likely greater than that of SO_3. true or [false]

e) The vapor pressure of SO_2 at 50 °C is likely greater than that of SO_3. [true] or false

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26 (2 each)

f) It is possible for one non-polar compound to have stronger IMFs than a different compound that is polar. [true] or false

g) If the partial pressure of a vapor is less than the liquid's vapor pressure, the current temperature is above the dew point. [true] or false

h) The vapor pressure of all liquids rises 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
either ok

Q5. Consider the following ionic compounds: KBr, $MgCl_2$, $MgBr_2$

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a) which has the lowest melting point: KBr ← lowest charges

b) which has the highest melting point: $MgCl_2$ ← high charges and smaller ions

Q6. 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.

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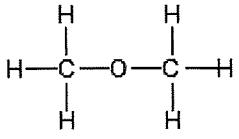

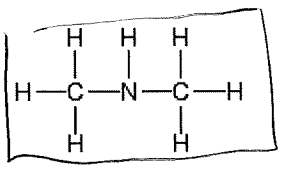

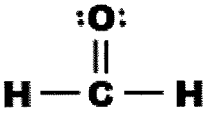

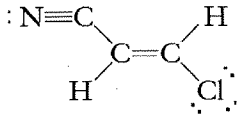

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Q7. What type of solid is each of the following: (choices: molecular, ionic, extended/covalent, metallic)

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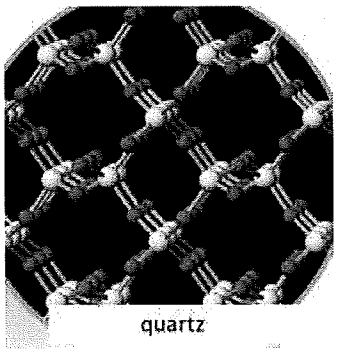
quartz: extended covalent

ice: molecular

potassium nitrate: ionic


quartz

Which of the above will have the weakest IMFs? ice

LONG ANSWER QUESTIONS: ALL WORK MUST BE SHOWN

Q8. 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.

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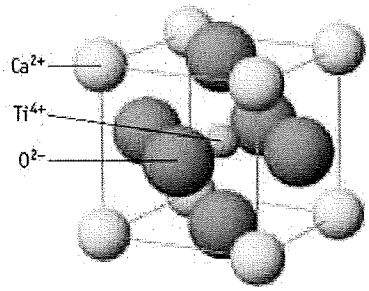

Ca 8 corners × 1/8 = 1 Ca

Ti 1 inside × 1 = 1 Ti

O 6 faces × 1/2 = 3 O

Formula: $CaTiO_3$

or $TiCaO_3$

Q9. 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/molecule after they vaporize.

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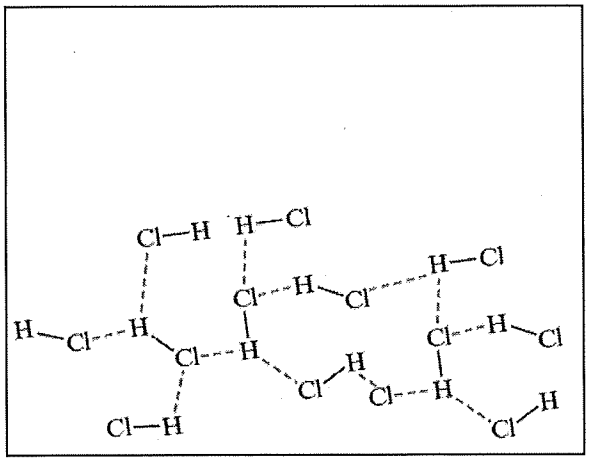

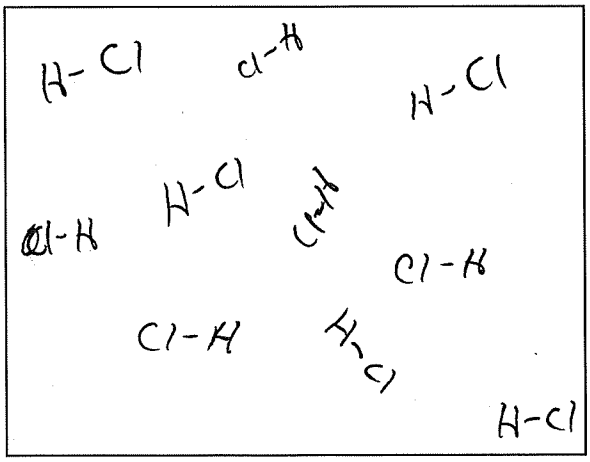

Separate molecules but don't break H from Cl

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Q10. Consider the phase diagram below.

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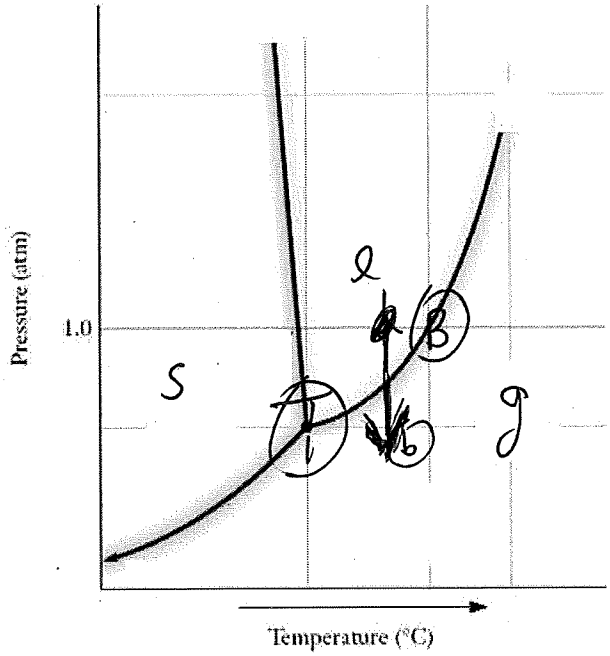

a. Label the regions for gas, liquid and solid.

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. Which is more dense:
the solid or (the liquid)

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.
You must show all your work.

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

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

propane = $CH_3CH_2CH_3$

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

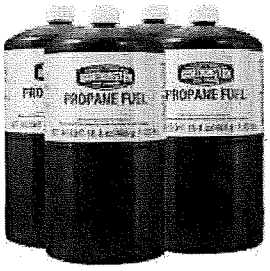
$$0.9094 = + \frac{\Delta H_{vap}}{8.314 J/K \cdot mol}\left[3.431 \times 10^{-4} K^{-1}\right]$$

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

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

22.0 **kJ/mol**

b) How much energy is required to vaporize all the propane in a 1-pound (454 g) container?



$$454g \; C_3H_8 \times \frac{1 mol \; C_3H_8}{44.11g} \times \frac{22.0 kJ}{mol \; C_3H_8} =$$

226 kJ

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hydrochloric

12. A bottle of concentrated ~~nitric~~ acid is 36% by weight HCl and has a density of 1.18 g/mL.

Calculate the following:

mole fraction HCl:

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$$\chi_{HCl} = \frac{0.985 \text{ mol HCl}}{0.985 \text{ mol HCl} + 3.55 \text{ mol } H_2O} = 0.217$$

assume 100g solution

$$36 \text{ g HCl} \times \frac{1 \text{ mol}}{36.55 \text{ g HCl}} = 0.985 \text{ mol HCl}$$

$$64 \text{ g } H_2O \times \frac{1 \text{ mol}}{18.02 \text{ g}} = 3.55 \text{ mol } H_2O$$

molality:

$$m_{HCl} = \frac{0.985 \text{ mol HCl}}{0.064 \text{ kg } H_2O} = 15.4 \text{ m}$$

molarity:

$$100 \text{ g solution} \times \frac{1 \text{ mL}}{1.18 \text{ g}} \times \frac{1 \text{ L}}{1000 \text{ mL}} = 0.0847 \text{ L}$$

$$M = \frac{0.985 \text{ mol HCl}}{0.0847 \text{ L}} = 11.6 \text{ M}$$

13. Use a Born-Haber cycle to calculate the lattice energy of **CuBr**(s) from the following thermodynamic data (all data is in kJ/mol).

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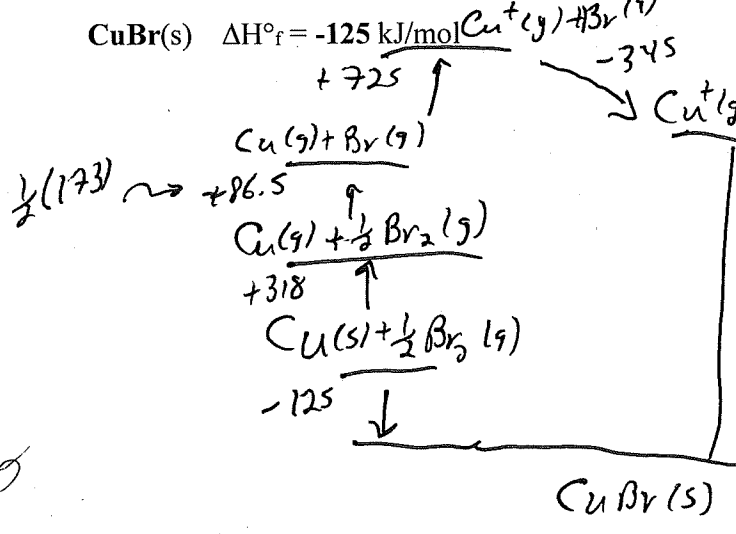
Cu(s)	$\Delta H_{sublimation}$ = **318** kJ/mol
Cu(g)	Ionization energy = **725** kJ/mol
Br-Br(g)	Bond energy = **173** kJ/mol
Br(g)	Electron affinity = **-345** kJ/mol
CuBr(s)	$\Delta H°_f$ = **-125** kJ/mol



$$U = [125 + 318 + 86.5 + 725 - 345] \text{ kJ}$$

$$= 909.5 \text{ kJ/mol}$$

$$= 910 \text{ kJ/mol}$$

$$U = 909.5 \text{ kJ/mol}$$

+ or − ok

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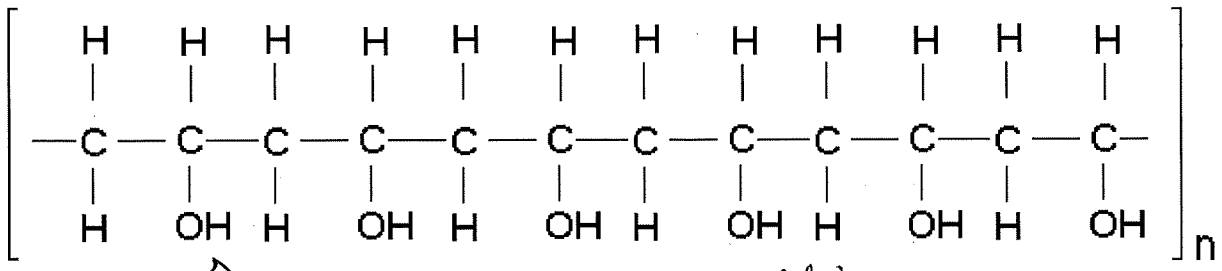
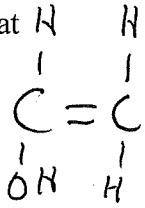
14. A portion of the structure of polyvinyl alcohol is shown below:



Is this an addition polymer or a condensation polymer? addition

Draw the structure of the monomer that is used to make this polymer:



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15. Metallic **gold** crystallizes in a **face-centered** cubic lattice, with one **Au** atom per lattice point. How many atoms are there per unit cell?

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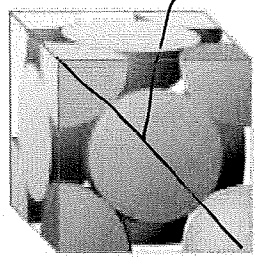
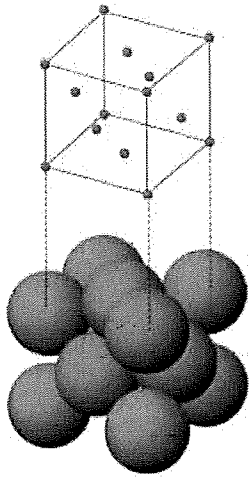
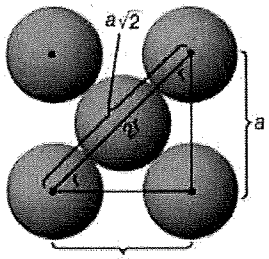


Unit cell

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



Unit cell



Cube face

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

$r_{Au} = \frac{577\,pm}{4} = 144\,pm$

What percentage of the unit cell is empty space?

Vol of atoms $= 4\,atoms \times \frac{4}{3}\pi (144\,pm)^3 = 4.99 \times 10^7\,pm^3$

unit cell volume $= (408\,pm)^3 = 6.79 \times 10^7\,pm^3$

% filled $= \frac{4.99}{6.79} \times 100 = 73.4\%$

% empty space $= (100 - 73.4)\% = 26.5\%$

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