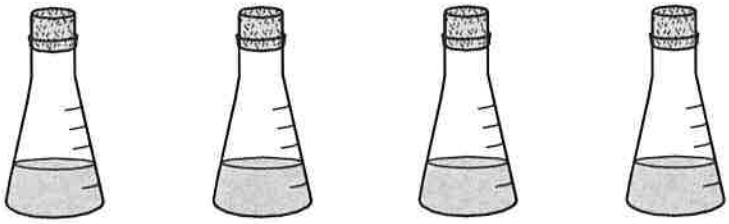
Answer EITHER Question 7 below OR Question 8 below. Only one of these two questions will be graded. If you start both questions, be sure to cross out the question you do not want graded. The Section II score weighting for the question you choose is 15 percent.



0.10 *M* NaF | 0.10 *M* $MgCl_2$ | 0.10 *M* C_2H_5OH | 0.10 *M* CH_3COOH

7. Answer the following questions, which refer to the 100 mL samples of aqueous solutions at 25°C in the stoppered flasks shown above.

   (a) Which solution has the lowest electrical conductivity? Explain.

   (b) Which solution has the lowest freezing point? Explain.

   (c) Above which solution is the pressure of water vapor greatest? Explain.

   (d) Which solution has the highest pH? Explain.

good bonding / IMF question while you are here :)

8. Answer the following questions using principles of chemical bonding and molecular structure.

   (a) Consider the carbon dioxide molecule, CO_2, and the carbonate ion, CO_3^{2-}.

      (i) Draw the complete Lewis electron-dot structure for each species.

      (ii) Account for the fact that the carbon-oxygen bond length in CO_3^{2-} is greater than the carbon-oxygen bond length in CO_2.

   (b) Consider the molecules CF_4 and SF_4.

      (i) Draw the complete Lewis electron-dot structure for each molecule.

      (ii) In terms of molecular geometry, account for the fact that the CF_4 molecule is nonpolar, whereas the SF_4 molecule is polar.

END OF EXAMINATION

6. Using principles of chemical bonding and molecular geometry, explain each of the following observations. Lewis electron-dot diagrams and sketches of molecules may be helpful as part of your explanations. For each observation, your answer must include references to both substances.

(a) The bonds in nitrite ion, NO_2^-, are shorter than the bonds in nitrate ion, NO_3^-.

(b) The CH_2F_2 molecule is polar, whereas the CF_4 molecule is not.

(c) The atoms in a C_2H_4 molecule are located in a single plane, whereas those in a C_2H_6 molecule are not.

(d) The shape of a PF_5 molecule differs from that of an IF_5 molecule.

(e) $HClO_3$ is a stronger acid than $HClO$.

5. (d) Xenon can react with oxygen and fluorine to form compounds such as XeO_3 and XeF_4. In the boxes provided, draw the complete Lewis electron-dot diagram for each of the molecules represented below.

XeO_3

XeF_4

(e) On the basis of the Lewis electron-dot diagrams you drew for part (d), predict the following:

(i) The geometric shape of the XeO_3 molecule & XeF_4

(ii) The hybridization of the valence orbitals of xenon in ~~XeF_4~~ XeO_3

(f) Predict whether the XeO_3 molecule is polar or nonpolar. Justify your prediction.

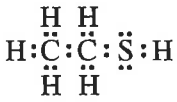
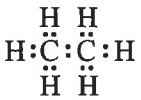
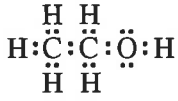
* Knowing, hybridization of atoms exceeding octet is not longer tested so sub XeO_3 instead ☺

a-c not included

Answer Question 5 and Question 6. The Section II score weighting for these questions is 15 percent each.

Your responses to these questions will be scored on the basis of the accuracy and relevance of the information cited. Explanations should be clear and well organized. Examples and equations may be included in your responses where appropriate. Specific answers are preferable to broad, diffuse responses.

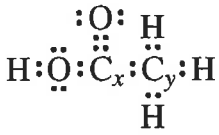
5. Use the information in the table below to respond to the statements and questions that follow. Your answers should be in terms of principles of molecular structure and intermolecular forces.

Compound	Formula	Lewis Electron-Dot Diagram
Ethanethiol	CH_3CH_2SH	
Ethane	CH_3CH_3	
Ethanol	CH_3CH_2OH	
Ethyne	C_2H_2	

(a) Draw the complete Lewis electron-dot diagram for ethyne in the appropriate cell in the table above.

(b) Which of the four molecules contains the shortest carbon-to-carbon bond? Explain.

(c) A Lewis electron-dot diagram of a molecule of ethanoic acid is given below. The carbon atoms in the molecule are labeled x and y, respectively.



Identify the geometry of the arrangement of atoms bonded to each of the following.

(i) Carbon x

(ii) Carbon y

(d) Energy is required to boil ethanol. Consider the statement "As ethanol boils, energy goes into breaking C–C bonds, C–H bonds, C–O bonds, and O–H bonds." Is the statement true or false? Justify your answer.

(e) Identify a compound from the table above that is nonpolar. Justify your answer.

(f) Ethanol is completely soluble in water, whereas ethanethiol has limited solubility in water. Account for the difference in solubilities between the two compounds in terms of intermolecular forces.

Nonmetal	C	N	O	Ne	Si	P	S	Ar
Formula of Compound	CF_4	NF_3	OF_2	No compound	SiF_4	PF_3	SF_2	No compound

5. Some binary compounds that form between fluorine and various nonmetals are listed in the table above. A student examines the data in the table and poses the following hypothesis: the number of F atoms that will bond to a nonmetal is always equal to 8 minus the number of valence electrons in the nonmetal atom.

(a) Based on the student's hypothesis, what should be the formula of the compound that forms between chlorine and fluorine?

(b) In an attempt to verify the hypothesis, the student researches the fluoride compounds of the other halogens and finds the formula ClF_3. In the box below, draw a complete Lewis electron-dot diagram for a molecule of ClF_3.

(c) Two possible geometric shapes for the ClF_3 molecule are trigonal planar and T-shaped. The student does some research and learns that the molecule has a dipole moment. Which of the two shapes is consistent with the fact that the ClF_3 molecule has a dipole moment? Justify your answer in terms of bond polarity and molecular structure.

In an attempt to resolve the existence of the ClF_3 molecule with the hypothesis stated above, the student researches the compounds that form between halogens and fluorine, and assembles the following list.

Halogen	Formula(s)
F	F_2
Cl	
Br	BrF, BrF_3, BrF_5
I	IF, IF_3, IF_5, IF_7

(d) Based on concepts of atomic structure and periodicity, propose a modification to the student's previous hypothesis to account for the compounds that form between halogens and fluorine.

8. Account for each of the following observations about pairs of substances. In your answers, use appropriate principles of chemical bonding and/or intermolecular forces. In each part, your answer must include references to both substances.

(a) Even though NH_3 and CH_4 have similar molecular masses, NH_3 has a much higher normal boiling point (−33°C) than CH_4 (−164°C).

(b) At 25°C and 1.0 atm, ethane (C_2H_6) is a gas and hexane (C_6H_{14}) is a liquid.

(c) Si melts at a much higher temperature (1,410°C) than Cl_2 (−101°C).

(d) MgO melts at a much higher temperature (2,852°C) than NaF (993°C).

END OF EXAMINATION

Answer EITHER Question 7 below OR Question 8 printed on page 13. Only one of these two questions will be graded. If you start both questions, be sure to cross out the question you do not want graded. The Section II score weighting for the question you choose is 15 percent.

7. Use appropriate chemical principles to account for each of the following observations. In each part, your response must include specific information about both substances.

   (a) At 25°C and 1 atm, F_2 is a gas, whereas I_2 is a solid.

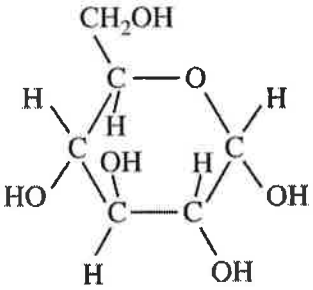
   (b) The melting point of NaF is 993°C, whereas the melting point of CsCl is 645°C.

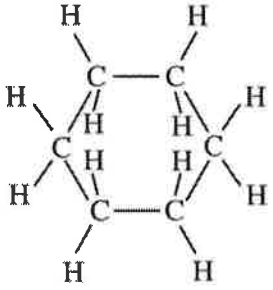
   (c) The shape of the ICl_4^- ion is square planar, whereas the shape of the BF_4^- ion is tetrahedral.

   (d) Ammonia, NH_3, is very soluble in water, whereas phosphine, PH_3, is only moderately soluble in water.

6. Answer each of the following in terms of principles of molecular behavior and chemical concepts.

(a) The structures for glucose, $C_6H_{12}O_6$, and cyclohexane, C_6H_{12}, are shown below.





Identify the type(s) of intermolecular attractive forces in

(i) pure glucose

(ii) pure cyclohexane

(b) Glucose is soluble in water but cyclohexane is not soluble in water. Explain.

(c) Consider the two processes represented below.

Process 1: $H_2O(l) \rightarrow H_2O(g)$ $\quad \Delta H^\circ = +44.0 \text{ kJ mol}^{-1}$

Process 2: $H_2O(l) \rightarrow H_2(g) + \frac{1}{2} O_2(g)$ $\quad \Delta H^\circ = +286 \text{ kJ mol}^{-1}$

(i) For each of the two processes, identify the type(s) of intermolecular or intramolecular attractive forces that must be overcome for the process to occur.

(ii) Indicate whether you agree or disagree with the statement in the box below. Support your answer with a short explanation.

When water boils, H_2O molecules break apart to form hydrogen molecules and oxygen molecules.

6. Answer the following questions related to sulfur and one of its compounds.

(a) Consider the two chemical species S and S^{2-}.

(i) Write the electron configuration (e.g., $1s^2\,2s^2\ldots$) of each species.

(ii) Explain why the radius of the S^{2-} ion is larger than the radius of the S atom.

(iii) Which of the two species would be attracted into a magnetic field? Explain.

(b) The S^{2-} ion is isoelectronic with the Ar atom. From which species, S^{2-} or Ar, is it easier to remove an electron? Explain.

(c) In the H_2S molecule, the H–S–H bond angle is close to 90°. On the basis of this information, which atomic orbitals of the S atom are involved in bonding with the H atoms?

(d) Two types of intermolecular forces present in liquid H_2S are London (dispersion) forces and dipole-dipole forces.

(i) Compare the strength of the London (dispersion) forces in liquid H_2S to the strength of the London (dispersion) forces in liquid H_2O. Explain.

(ii) Compare the strength of the dipole-dipole forces in liquid H_2S to the strength of the dipole-dipole forces in liquid H_2O. Explain.

hybrid anomaly -- they point it out

STOP

END OF EXAM

Answer Question 5 and Question 6. The Section II score weighting for these questions is 15 percent each.

Your responses to these questions will be scored on the basis of the accuracy and relevance of the information cited. Explanations should be clear and well organized. Examples and equations may be included in your responses where appropriate. Specific answers are preferable to broad, diffuse responses.

Process	$\Delta H°$ (kJ/mol$_{rxn}$)
$Br_2(l) \rightarrow Br_2(g)$	30.91
$I_2(s) \rightarrow I_2(g)$	62.44

5. At 298 K and 1 atm, the standard state of Br_2 is a liquid, whereas the standard state of I_2 is a solid. The enthalpy changes for the formation of $Br_2(g)$ and $I_2(g)$ from these elemental forms at 298 K and 1 atm are given in the table above.

   (a) Explain why $\Delta H°$ for the formation of $I_2(g)$ from $I_2(s)$ is larger than $\Delta H°$ for the formation of $Br_2(g)$ from $Br_2(l)$. In your explanation identify the type of particle interactions involved and a reason for the difference in magnitude of those interactions.

   (b) Predict which of the two processes shown in the table has the greater change in entropy. Justify your prediction.

   (c) $I_2(s)$ and $Br_2(l)$ can react to form the compound $IBr(l)$. Predict which would have the greater molar enthalpy of vaporization, $IBr(l)$ or $Br_2(l)$. Justify your prediction.

An experiment is performed to compare the solubilities of $I_2(s)$ in different solvents, water and hexane (C_6H_{14}). A student adds 2 mL of H_2O and 2 mL of C_6H_{14} to a test tube. Because H_2O and C_6H_{14} are immiscible, two layers are observed in the test tube. The student drops a small, purple crystal of $I_2(s)$ into the test tube, which is then corked and inverted several times. The C_6H_{14} layer becomes light purple, while the H_2O layer remains virtually colorless.

   (d) Explain why the hexane layer is light purple while the water layer is virtually colorless. Your explanation should reference the relative strengths of interactions between molecules of I_2 and the solvents H_2O and C_6H_{14}, and the reasons for the differences.

$\Delta H°$: energy require to vaporize the substance
(called either $\Delta H°$ of formation or Molar enthalpy

(e) The student then adds a small crystal of KI(*s*) to the test tube. The test tube is corked and inverted several times. The I^- ion reacts with I_2 to form the I_3^- ion, a linear species.

(i) In the box below, draw the complete Lewis electron-dot diagram for the I_3^- ion.

(ii) In which layer, water or hexane, would the concentration of I_3^- be higher? Explain.

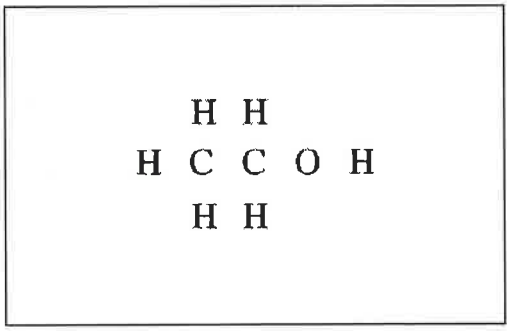
6. Answer the following questions using principles of molecular structure and intermolecular forces.

Compound	Empirical Formula	Solubility in Water	Boiling Point (°C)
1	C_2H_6O	Slightly soluble	−24
2	C_2H_6O	Soluble	78

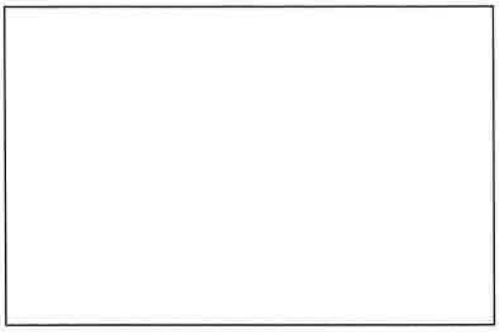
Compounds 1 and 2 in the data table above have the same empirical formula, but they have different physical properties.

(a) The skeletal structure for one of the two compounds is shown below in Box X.

(i) Complete the Lewis electron-dot diagram of the molecule in Box X. Include any lone (nonbonding) pairs of electrons.



Box X

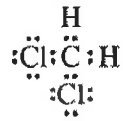
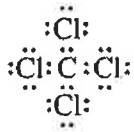


Box Y

(ii) In Box Y above, draw the complete Lewis electron-dot diagram for the other compound, which is a structural isomer of the compound represented in Box X. Include any lone (nonbonding) pairs of electrons.

(b) On the basis of the complete Lewis electron-dot diagrams you drew in part (a) and the information in the data table above, identify which compound, 1 or 2, has the structure represented in Box X. Justify your answer in terms of the intermolecular forces present in each compound.

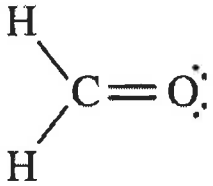
Use the information in the following table to answer parts (c) and (d).

Name	Lewis Electron-Dot Diagram	Boiling Point (°C)	Vapor Pressure at 20°C (mm Hg)
Dichloromethane		39.6	353
Carbon tetrachloride		76.7	89

(c) Dichloromethane has a greater solubility in water than carbon tetrachloride has. Account for this observation in terms of the intermolecular forces between <u>each</u> of the solutes and water.

(d) In terms of intermolecular forces, explain why dichloromethane has a higher vapor pressure than carbon tetrachloride.

(e) The complete Lewis electron-dot diagram of methanal (formaldehyde) is shown in the box below. Molecules of methanal can form hydrogen bonds with water. In the box below, draw a water molecule in a correct orientation to illustrate a hydrogen bond between a molecule of water and the molecule of methanal. Use a dashed line to represent the hydrogen bond.



STOP

END OF EXAM