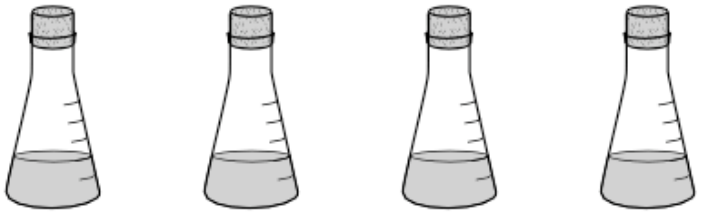
1999



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.

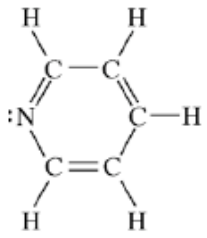
   (c) Above which solution is the pressure of water vapor greatest? Explain.

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

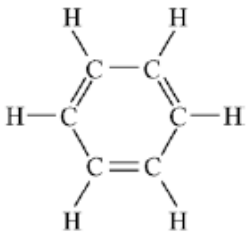
2008

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

   (a) Structures of the pyridine molecule and the benzene molecule are shown below. Pyridine is soluble in water, whereas benzene is not soluble in water. Account for the difference in solubility. You must discuss <u>both</u> of the substances in your answer.

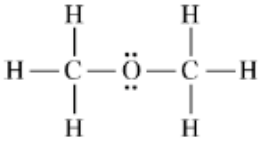


Pyridine

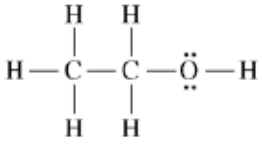


Benzene

   (b) Structures of the dimethyl ether molecule and the ethanol molecule are shown below. The normal boiling point of dimethyl ether is 250 K, whereas the normal boiling point of ethanol is 351 K. Account for the difference in boiling points. You must discuss <u>both</u> of the substances in your answer.



Dimethyl Ether



Ethanol

   (c) SO_2 melts at 201 K, whereas SiO_2 melts at 1,883 K. Account for the difference in melting points. You must discuss <u>both</u> of the substances in your answer.

   (d) The normal boiling point of $Cl_2(l)$ (238 K) is <u>higher</u> than the normal boiling point of $HCl(l)$ (188 K). Account for the difference in normal boiling points based on the types of intermolecular forces in the substances. You must discuss <u>both</u> of the substances in your answer.

2001

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).

2003 #6

6. For each of the following, use appropriate chemical principles to explain the observation. Include chemical equations as appropriate.

(a) In areas affected by acid rain, statues and structures made of limestone (calcium carbonate) often show signs of considerable deterioration.

(b) When table salt (NaCl) and sugar ($C_{12}H_{22}O_{11}$) are dissolved in water, it is observed that

(i) both solutions have higher boiling points than pure water, and

(ii) the boiling point of 0.10 *M* NaCl(*aq*) is higher than that of 0.10 *M* $C_{12}H_{22}O_{11}(aq)$.

(c) Methane gas does not behave as an ideal gas at low temperatures and high pressures.

(d) Water droplets form on the outside of a beaker containing an ice bath.

2003 #8

Compound Name	Compound Formula	ΔH°_{vap} (kJ mol^{-1})
Propane	$CH_3CH_2CH_3$	19.0
Propanone	CH_3COCH_3	32.0
1-propanol	$CH_3CH_2CH_2OH$	47.3

8. Using the information in the table above, answer the following questions about organic compounds.

(a) For propanone,

(i) draw the complete structural formula (showing all atoms and bonds);

(ii) predict the approximate carbon-to-carbon-to-carbon bond angle.

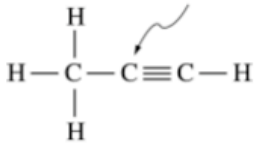
(b) For each pair of compounds below, explain why they do not have the same value for their standard heat of vaporization, ΔH°_{vap}. (You must include specific information about both compounds in each pair.)

(i) Propane and propanone

(ii) Propanone and 1-propanol

(c) Draw the complete structural formula for an isomer of the molecule you drew in part (a) (i).

(d) Given the structural formula for propyne below,



(i) indicate the hybridization of the carbon atom indicated by the arrow in the structure above;

(ii) indicate the total number of sigma (σ) bonds and the total number of pi (π) bonds in the molecule.

2004

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.

2005

7. Use principles of atomic structure, bonding, and/or intermolecular forces to respond to each of the following. Your responses must include specific information about all substances referred to in each question.

(a) At a pressure of 1 atm, the boiling point of $NH_3(l)$ is 240 K, whereas the boiling point of $NF_3(l)$ is 144 K.

(i) Identify the intermolecular force(s) in each substance.

(ii) Account for the difference in the boiling points of the substances.

(b) The melting point of $KCl(s)$ is 776°C, whereas the melting point of $NaCl(s)$ is 801°C.

(i) Identify the type of bonding in each substance.

(ii) Account for the difference in the melting points of the substances.

(c) As shown in the table below, the first ionization energies of Si, P, and Cl show a trend.

Element	First Ionization Energy ($kJ\ mol^{-1}$)
Si	786
P	1,012
Cl	1,251

(i) For each of the three elements, identify the quantum level (e.g., $n = 1$, $n = 2$, etc.) of the valence electrons in the atom.

(ii) Explain the reasons for the trend in first ionization energies.

(d) A certain element has two stable isotopes. The mass of one of the isotopes is 62.93 amu and the mass of the other isotope is 64.93 amu.

(i) Identify the element. Justify your answer.

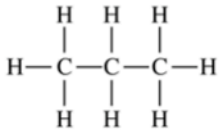
(ii) Which isotope is more abundant? Justify your answer.

2005B

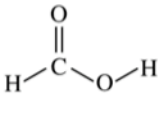
8.(a) Draw a complete Lewis electron-dot structure for the CS_2 molecule. Include all valence electrons in your structure.

(b) The carbon-to-sulfur bond length in CS_2 is 160 picometers. Is the carbon-to-selenium bond length in CSe_2 expected to be greater than, less than, or equal to this value? Justify your answer.

(c) The bond energy of the carbon-to-sulfur bond in CS_2 is 577 kJ mol^{-1}. Is the bond energy of the carbon-to-selenium bond in CSe_2 expected to be greater than, less than, or equal to this value? Justify your answer.



Propane



Methanoic Acid

(d) The complete structural formulas of propane, C_3H_8, and methanoic acid, HCOOH, are shown above. In the table below, write the type(s) of intermolecular attractive force(s) that occur in each substance.

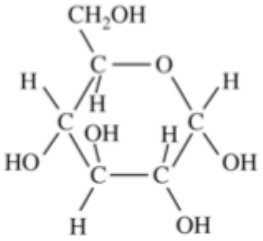
Substance	Boiling Point	Intermolecular Attractive Force(s)
Propane	229 K	
Methanoic acid	374 K	

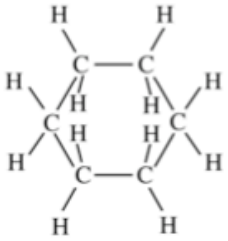
(e) Use principles of intermolecular attractive forces to explain why methanoic acid has a higher boiling point than propane.

2006

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

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