

AP Questions: IMF's and Phase Diagrams

1973 D

Discuss briefly the relationship between the dipole moment of a molecule and the polar character of the bonds within it. With this as the basis, account for the difference between the dipole moments of CH_2F_2 and CF_4 .

1974 D

The boiling points of the following compounds increase in the order in which they are listed below:



Discuss the theoretical considerations involved and use them to account for this order.

1979 D

Butane, chloroethane, acetone, and 1-propanol all have approximately the same molecular weights. Data on their boiling points and solubilities in water are listed in the table below.

Compound	Formula	Boiling Pt.(°C)	Solubility in water
Butane	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$	0	insoluble
Chloroethane	$\text{CH}_3\text{CH}_2\text{Cl}$	12	insoluble
Acetone	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3\text{C} \text{ C} \text{ CH}_3 \end{array}$	56	completely miscible
1-Propanol	$\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$	97	completely miscible

On the basis of dipole moments (molecular polarities) and/or hydrogen bonding, explain in a qualitative way the differences in the

- boiling points of butane and chloroethane.
- water solubilities of chloroethane and acetone.
- water solubilities of butane and 1-propanol.
- boiling points of acetone and 1-propanol.

1985 D

Substance	Melting Point, °C
H_2	-259
C_3H_8	-190
HF	-92
CsI	621
LiF	870
SiC	>2,000

- Discuss how the trend in the melting points of the substances tabulated above can be explained in terms of the types of attractive forces and/or bonds in these substances.
- For any pairs of substances that have the same kind(s) of attractive forces and/or bonds, discuss the factors that cause variations in the strengths of the forces and/or bonds.

1988 D

Using principles of chemical bonding and/or intermolecular forces, explain each of the following.

- Xenon has a higher boiling point than neon has.
- Solid copper is an excellent conductor of electricity, but solid copper chloride is not.
- SiO_2 melts at a very high temperature, while CO_2 is a gas at room temperature, even though Si and C are in the same chemical family.
- Molecules of NF_3 are polar, but those of BF_3 are not.

1988

The normal boiling and freezing points of argon are 87.3 K and 84.0 K, respectively. The triple point is at 82.7 K and 0.68 atmosphere.

- Use the data above to draw a phase diagram for argon. Label the axes and label the regions in which the solid, liquid, and gas phases are stable. On the phase diagram, show the position of the normal boiling point.
- Describe any changes that can be observed in a sample of solid argon when the temperature is increased from 40 K to 160 K at a constant pressure of 0.50 atmosphere.
- Describe any changes that can be observed in a sample of liquid argon when the pressure is reduced from 10 atmospheres to 1 atmosphere at a constant temperature of 100 K, which is well below the critical temperature.
- Does the liquid phase of argon have a density greater than, equal to, or less than the density of the solid phase? Explain your answer, using information given in the introduction to this question.

1989 D

The melting points of the alkali metals decrease from Li to Cs. In contrast, the melting points of the halogens increase from F_2 to I_2 .

- Using bonding principles, account for the decrease in the melting points of the alkali metals.
- Using bonding principles, account for the decrease in the melting points of the halogens.
- What is the expected trend in the melting points of the compounds LiF , NaCl , KBr , and CsI ? Explain this trend using bonding principles.

1991

Experimental data provide the basis for interpreting differences in properties of substances.

TABLE 1

Compound	Melting Point ($^{\circ}\text{C}$)	Electrical Conductivity of Molten State (ohm^{-1})
BeCl_2	405	0.086
MgCl_2	714	> 20
SiCl_4	-70	0
MgF_2	1,261	> 20

TABLE 2

Substance	Bond Length (angstroms)
F_2	1.42
Br_2	2.28
N_2	1.09

Account for the differences in properties given in Tables 1 and 2 above in terms of the differences in structure and bonding in each of the following pairs.

- MgCl_2 and SiCl_4
- MgCl_2 and MgF_2
- F_2 and Br_2
- F_2 and N_2

1992 D

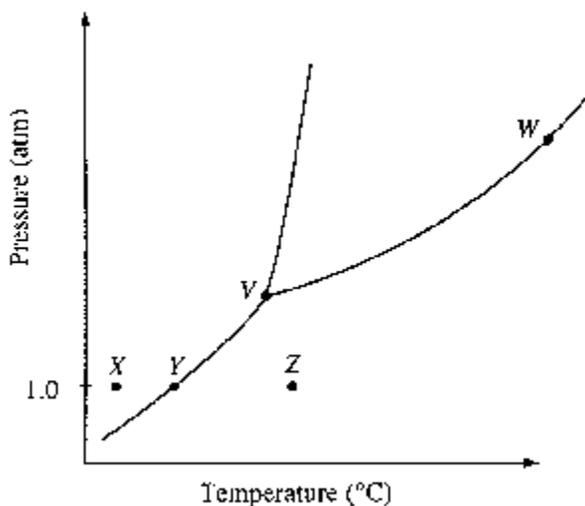
Explain each of the following in terms of atomic and molecular structures and/or intermolecular forces.

- Solid K conducts an electric current, whereas solid KNO_3 does not.
- SbCl_3 has measurable dipole moment, whereas SbCl_5 does not.
- The normal boiling point of CCl_4 is 77°C , whereas that of CBr_4 is 190°C .
- $\text{NaI}(\text{s})$ is very soluble in water, whereas $\text{I}_2(\text{s})$ has a solubility of only 0.03 gram per 100 grams of water.

1995 D

Explain the following in terms of the electronic structure and bonding of the compounds considered.

- Liquid oxygen is attracted to a strong magnet, whereas liquid nitrogen is not.
- The SO_2 molecule has a dipole moment, whereas the CO_2 molecule has no dipole moment. Include the Lewis (electron-dot) structures in your explanation.
- Halides of cobalt(II) are colored, whereas halides of zinc(II) are colorless.
- A crystal of high purity silicon is a poor conductor of electricity; however, the conductivity increases when a small amount of arsenic is incorporated (doped) into the crystal.

1995

- What does point V represent? What characteristics are specific to the system only at point V ?
- What does each point on the curve between V and W represent?
- Describe the changes that the system undergoes as the temperature slowly increases from X to Y to Z at 1.0 atmosphere.
- In a solid-liquid mixture of this substance, will the solid float or sink? Explain.

1996 D

Explain each of the following observations in terms of the electronic structure and/or bonding of the compounds involved.

- At ordinary conditions, HF (normal boiling point = 20°C) is a liquid, whereas HCl (normal boiling point = -114°C) is a gas.
- Molecules of AsF_3 are polar, whereas molecules of AsF_5 are nonpolar.
- The N-O bonds in the NO_2^- ion are equal in length, whereas they are unequal in HNO_2 .
- For sulfur, the fluorides SF_2 , SF_4 , and SF_6 are known to exist, whereas for oxygen only OF_2 is known to exist.

1997 D (Required)

Consider the molecules PF_3 and PF_5 .

- Draw the Lewis electron-dot structures for PF_3 and PF_5 and predict the molecular geometry of each.
- Is the PF_3 molecule polar, or is it nonpolar? Explain.
- On the basis of bonding principles, predict whether each of the following compounds exists. In each case, explain your prediction.
 - NF_5
 - AsF_5

1998 D

Answer each of the following using appropriate chemical principles.

- Dimethyl ether, $\text{H}_3\text{C-O-CH}_3$, is not very soluble in water. Draw a structural isomer of dimethyl ether that is much more soluble in water and explain the basis of its increased water solubility.

In each case, justify your choice.

1999 D

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

- Consider the molecules CF_4 and SF_4 .
 - Draw the complete Lewis electron-dot structure for each molecule.
 - In terms of molecular geometry, account for the fact that the CF_4 molecule is nonpolar, whereas the SF_4 molecule is polar.

2000 D

Answer the following questions about the element selenium, Se (atomic number 34).

- Selenium reacts with fluorine to form SeF_4 . Draw the complete Lewis electron-dot structure for SeF_4 and sketch the molecular structure. Indicate whether the molecule is polar or nonpolar, and justify your answer.

2001 D

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.

- 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).
- At 25°C and 1.0 atm, ethane (C_2H_6) is a gas and hexane (C_6H_{14}) is a liquid.
- Si melts at a much higher temperature ($1,410^\circ\text{C}$) than Cl_2 (-101°C).
- MgO melts at a much higher temperature ($2,852^\circ\text{C}$) than NaF (993°C).

2002 D

Use the principles of atomic structure and/or chemical bonding to explain each of the following. In each part, your answer must include references to both substances.

- The boiling point of Cl_2 is lower than the boiling point of Br_2 .