13 • IMF's & Phase Changes

ANSWERS TO FREE RESPONSE QUESTIONS

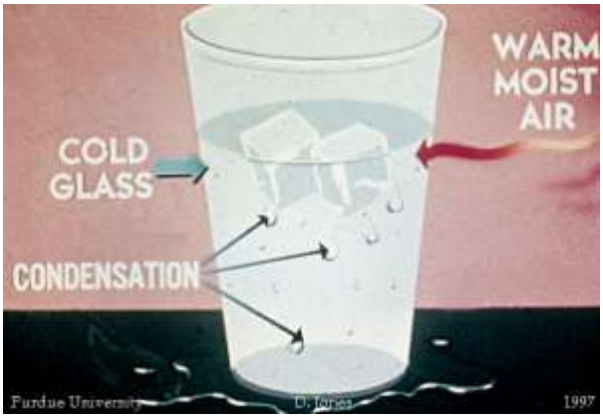
2003 D

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

At low temperatures and high pressures, the methane molecules are slow and closer together. Under these conditions, the London Dispersion Forces become significant and creates a deviation from ideal behavior.

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

As water vapor molecules collide with the cool beaker, the molecules lose kinetic energy, slow down, attract each other due to hydrogen bonding, and condense into a liquid.



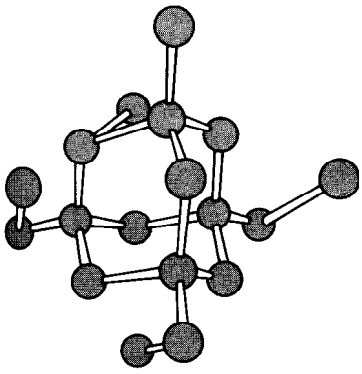
1994 D

(b) At room temperature, NH_3 is a gas and H_2O is a liquid, even though NH_3 has a molar mass of 17 grams and H_2O has a molar mass of 18 grams.

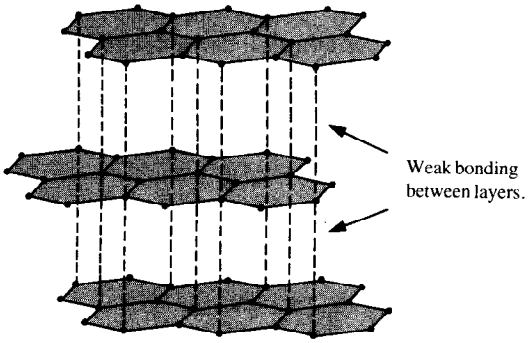
While both NH_3 and H_2O exhibit hydrogen bonding, H_2O is more effective. The O in H_2O has <u>two</u> lone pairs to accept H-bonds and <u>two</u> H's to make H-bonds. The N in NH_3 has only <u>one</u> lone pair to accept a bond while it has three H's to make H-bonds. NH_3 can not create an effective a network of H-bonds.

(c) C (graphite) is used as a lubricant, whereas C (diamond) is used as an abrasive.

Diamond, the hardest naturally occurring substance, has each carbon atom surrounded by a tetrahedral arrangement of other carbon atoms (see drawing). The network solid structure is stabilized by covalent bonds, formed by the overlap of sp^3 hybridized carbon atomic orbitals. A diamond has uniform very strong bonds in all directions in the crystal.



Diamond

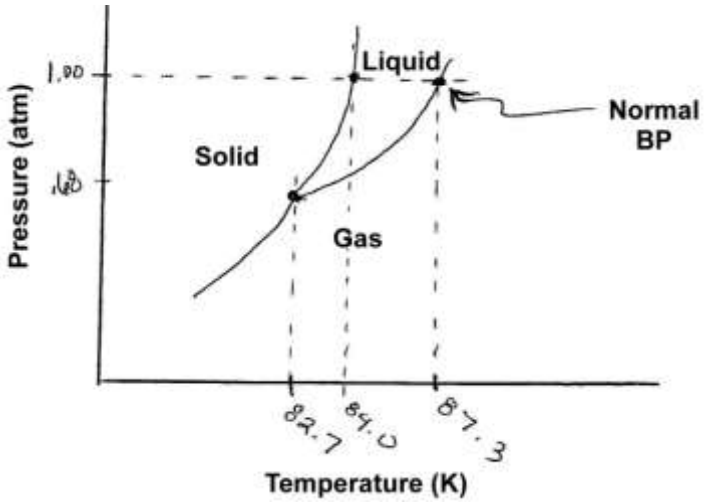


Graphite

Graphite has a different kind of bonding based on layers of carbon atoms arranged in fused six-member rings (see drawing). Each carbon atom in a layer is surrounded by three other carbons in a trigonal planar arrangement with 120° bond angles. The slipperiness is caused by noting that graphite has very strong bonds within layers but weak bonding (London Dispersion Forces) between the layers which allows the layers to slide past one another quite readily.

1988 Answers:

(a) Use the numbers in the question to plot the triple point and the normal melting and boiling points. Sketch the rest of the phase diagram based on the general shape of a phase diagram.



(b) The argon ***sublimes***. You can estimate on the phase diagram that at 40 K and 0.50 atm, the Ar will be a ***solid***. At 0.50 atm and 160 K, Ar will be a ***gas***.

(c) The argon ***vaporizes***. At 10 atm pressure the Ar will be a ***liquid*** and when the pressure drops to 1 atm at 100 K, it will be a ***gas***.

(d) ***The liquid phase is less dense than the solid phase.*** Since the freezing point of argon is higher than the triple point temperature, the solid-liquid equilibrium line slopes to the right with increasing pressure. Thus, if a sample of liquid argon is compressed (pressure increased) at constant temperature, the liquid becomes a solid. Because increasing pressure favors the denser phase, solid argon must be the denser phase.