

2014 Solutions Practice Problems

1975 D

Alcohol dissolves in water to give a solution that boils at a lower temperature than pure water. Salt dissolves in water to give a solution that boils at a higher temperature than pure water. Explain these facts from the standpoint of vapor pressure.

1984 C

Give a scientific explanation for the following observations. Use equations or diagrams if they are relevant.

- It takes longer to cook an egg until it is hard-boiled in Denver (altitude 1 mile above sea level) than it does in New York City (near sea level).
- Burn coal containing a significant amount of sulfur leads to "acid rain"
- Perspiring is a mechanism for cooling the body.
- The addition of antifreeze to water in a radiator decreases the likelihood that the liquid in the radiator will either freeze or boil.

1986 D

Give a scientific explanation for each of the following observations. Use equations or diagrams if they seem relevant.

- Graphite is used to make electrodes, while diamond, another allotrope of carbon, is a very poor conductor of electricity.
- Putting rock salt on an icy driveway melts the ice even when the air temperature is -10°C .
- Carbon dioxide, rather than a stream of water, should be used to extinguish an oil fire.

1987 D

In 1884 the Swedish chemist Svante Arrhenius proposed that salts dissociate into two or more separate, independent, ionic fragments when they dissolve in water.

- Give one piece of experimental evidence that more than 1 mole of particles is formed when 1 mole of a salt dissolves in water.
- Give one piece of experimental evidence that the particles formed when a salt dissolves in water are charged.
- Explain why the heat of neutralization is always the same when 1 mole of any monoprotic strong acid reacts with enough strong base to form a neutral solution.
- Explain why hydrogen chloride, HCl , dissociated when it dissolves in water but not when it dissolves in benzene.

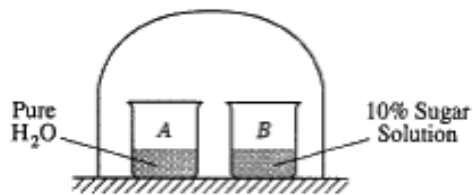
1988 D

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.

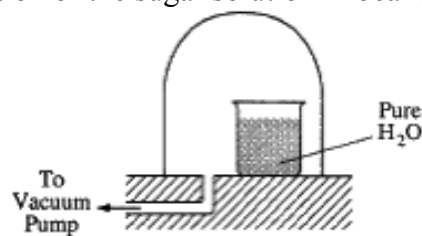
- Use the data above to draw a phase diagram for argon. Label the axes and label the regions in which the solid, liquid and gas phases are stable. On the phase diagram, show the position of the normal boiling point.
- Describe any changes that can be observed in a sample of solid argon when the temperature 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.

1994 D

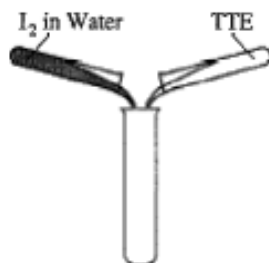
Discuss the following phenomena in terms of the chemical and physical properties of the substances involved and general principles of chemical and physical change.



- (a) As the system shown above approaches equilibrium, what change occurs to the volume of water in beaker A? What happens to the concentration of the sugar solution in beaker B? Explain why these changes occur.

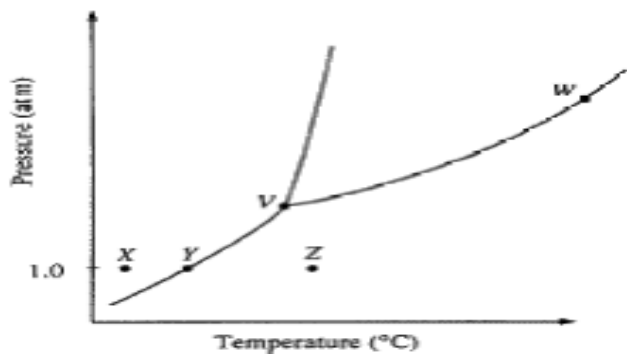


- (b) A bell jar connected to a vacuum pump is shown above. As the air pressure under the bell jar decreases, what behavior of water in the beaker will be observed? Explain why this occurs.



- (c) A water solution of I_2 is shaken with an equal volume of a nonpolar solvent such as TTE (trichlorotrifluoroethane). Describe the appearance of this system after shaking. (A diagram may be helpful.) Account for this observation.

1995 D



The phase diagram for a pure substance is shown above. Use this diagram and your knowledge about changes of phase to answer the following questions.

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

1975 D Answer:

An alcohol-water solution has a higher than normal (pure water) vapor pressure because alcohol is a volatile solute and contributes substantially to the vapor of the solution. The higher the vapor pressure, the lower the boiling point. A salt-water solution has a lower than normal vapor because salt is a non-volatile solute and solute-solvent interaction decrease the vapor of the solution, the lower the vapor pressure, the higher the boiling point.

1984 C Answer:

- (a) Water boils at a lower temperature in Denver than in NYC because the atmospheric pressure is less at high altitudes. At a lower temperature, the cooking process is slower, so the time to prepare a hard-boiled egg is longer.
- (b) $S + O_2 \rightarrow SO_2$ (as coal is burned)
 $SO_2 + H_2O \rightarrow H_2SO_3$ (in the atmosphere)
 H_2SO_3 is sulfurous acid.
- (c) Vaporization or evaporation of sweat from the skin is an endothermic process and takes heat from the body and so cool the skin.
- (d) Colligative properties, which depend on the number of particles present, are involved.
Solute (the antifreeze) causes the lowering of the vapor pressure of the solvent. When the vapor pressure of the solvent is lowered, the freezing point is lowered and the boiling point is raised.

1986 D Answer:

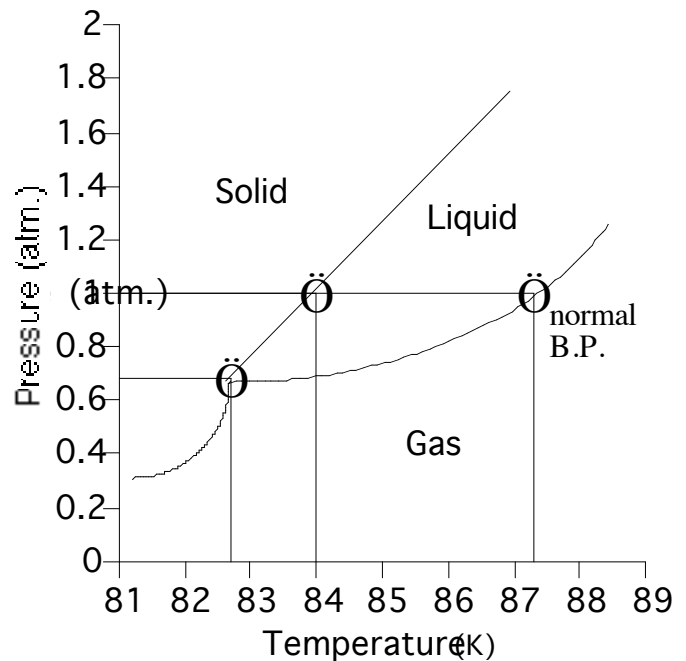
- (a) Distinction or correctly implied distinction between the structures of graphite and diamond.
Freedom of movement of electrons in graphite resulting from the structure.
- (b) The rock salt forms a concentrated solution with very little water from the ice. The solution now has a freezing point lower than the temperature of the ice, therefore, the ice melts.
- (c) Carbon dioxide is more dense than air and so pushes the air away from the fire.
Water is more dense than the oil and so ends up below the oil, leaving the oil still in contact with the air; or the hot burning oil quickly vaporizes the water creating steam that spatters the oil into the air.

1987 D Answer:

- (a) The freezing point depression (or any colligative effect) that occurs when a mole of a salt is dissolved is greater than when a mole of a non-dissociated substance is dissolved. (The greater the number of solute particles the greater the colligative effect.)
- (b) The solution of a salt conducts electricity.
- (c) Every neutralization between a strong acid and a strong base involves the same reaction:
$$H^+(aq) + OH^-(aq) \rightarrow H_2O$$
since both the strong acid and the strong base are completely dissociated. Spectator ions have no appreciable effect.
- (d) Because of the polar nature of water, it is capable of solvating the ions that result from the dissociation, whereas the nonpolar benzene interacts very weakly with these ions. OR
Because of the greater dielectric constant of water, it is better able to separate the ions.

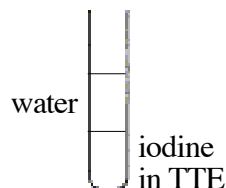
1988 D Answer:

- (a)
- (b) The argon sublimes.
- (c) The argon vaporizes.
- (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.



1994 D Answer:

- (a) volume of water decreases while the concentration of sugar solution decreases. Pure water has a higher vapor pressure than does the 10% sugar solution and when equilibrium is reached the water will evaporate and the solution will increase in volume.
- (b) The water will boil when the pressure in the bell jar reaches the vapor pressure of the water. Boiling occurs when the vapor pressure of the liquid is in equilibrium with the pressure above the liquid.
- (c) (i) Water and TTE will form separate layers because the polar water is not miscible with the non-polar TTE.



- (ii) The TTE will be the bottom layer because its density is greater than the water.
- (iii) The non-polar iodine will dissolve better in the non-polar TTE and form a pinkish-purple tint.

1995 D Answer:

- (a) Triple point. All three states of the substance coexist (equilibrium); the solid and the liquid have identical vapor pressures.
- (b) Curve *VW* represents the equilibrium between the liquid and its vapor. Along this line the liquid will be boiling. The points represent the vapor pressure of the liquid as a function of temperature.
- (c) At point *X* the substance is a solid, as its temperature increases (at constant pressure), at point *Y* the solid is in equilibrium with its vapor and will sublime. From point *Y* to *Z* it exist only as a vapor.
- (d) Sink. A positive slope of the solid-liquid line indicates that the solid is denser than its liquid and, therefore, will sink.