AP® Chemistry
2003 Sample Student Responses

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6A,

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.

a) When exposed to acid, the limestone ($CaCO_3$) reacts with it as shown by the following equation

$H^+ + CaCO_3 \rightarrow H_2O + CO_2 + Ca^{2+}$

Thus the limestone deteriorates giving off CO_2 gas and water

b) i) When non volatile ~~solutes~~ Solutes such as NaCl and $C_{12}H_{22}O_{11}$ are dissolved in water, they decrease the vapor pressure because they interfere with the amount of space $H_2O_{(g)}$ has to escape. Thus, a higher temperature is needed in order for the vapor pressure of the solution to equal the ~~vapor~~ pressure of the atm (the boiling point).

ii) $\Delta T_b = i K_b \times$ molality. For NaCl, which dissociates, the i value is 2, whereas in sugar, the value is 1. Thus, because NaCl has more particles dissociated than sugar, these particles will interfere with the escaping water molecules more, decreasing the vapor pressure and increasing boiling point.

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ADDITIONAL PAGE FOR ANSWERING QUESTION 6.

c) Gases only behave idealy, that is no inter molecular forces and negligable volume, at high temperatures and low pressure. At low temperatures and high volume, however, methane does have significant inter molecular forces that the kinetic energy of the particles cannot overcome and also has significant volume because at higher pressures, where the molecules packed closer together, the volume of each particle becomes significant.

d) Water droplets form on the outside of an ice bath because of temperature. When water vapor in the air contacts the cool glass of the beaker, kinetic energy from the vapor is transferred to the beaker in an effort to achieve the same ~~temperature~~ energy. Thus the water vapor ~~has~~ loses ~~kinetic energy~~ enough kinetic energy that the inter molecular forces become significan, ~~enough~~ condensing the water vapor into liquid on the surface of the beaker.

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(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.

A) limestone is $CaCO_3$, when the acidic water comes into contact with the Limestone a reaction takes place. $H^+ + CaCO_3 \rightarrow Ca^{+2} + H_2CO_3$ and H_2CO_3 immediate decomposes into $H_2O + CO_2$. So as the acid rain comes into contact with the limestone the lime stone is decomposed in $Ca^+ + H_2O +$ and CO_2.

B)(i) Boiling point elevation is due to the fact that by dissolving the 2 substances in water you lower the Vapor Pressure of H_2O above the solution. This is because water molecules are needed to keep the NaCl + $C_{12}H_{22}O_{11}$ dissolved so not as much is able to evaporate. Solutions boil when the vapor pressure of the solution equals the atmospheric pressure. With a lower starting vapor pressure the solutions take longer to reach the atmospheric pressure.

(ii) The boiling point of the NaCl solution is higher than the sugar solution because NaCl also dissociates into $Na^+ + Cl^-$ ions. So there are twice as many particles floating around in solution than in the $C_{12}H_{22}O_{11}$ solution. Because there are 2 as many things floating around the VP is lower than in the $C_{12}H_{22}O_{11}$ solution.

ADDITIONAL PAGE FOR ANSWERING QUESTION 6.

C) Methane gas doesn't behave as an ideal gas at low temps. and high pressures because the assumptions about ideal gases are wrong. An ideal gas has neither size nor mass. It is thought of as a point, it is also thought to not interact with any of the other gas particles. But at low temps when the gas particles are moving much slower the inter-particle forces affect how each particle moves. At high pressures, when there a alot of gas the particles bump into each other, get in each others way + this affects its behavior.

D) There is water vapor on the air. When water vapor hits a cool beaker containing an ice bath some of its energy is transferred to the beaker. When a water vapor molecule loses enough energy it becomes a liquid again. It will stick to the side of the ice bath. When enough molecules stick droplets of water form.

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

a. The decomposition of a metallic carbonate with acid yields Carbon dioxide. Some carbon from the carbonate is lost so the limestone would deteriorate

b i. The boiling point of a solution is greater than the boiling point of the pure solvent

ii. $C_{12}H_{22}O_{11}$ does not ionize in water, ~~the~~ while NaCl ionizes into 2 ions compared to 1 of sugar.

c. at low temperatures the movement of the molecules slows because the kinetic energy is reduced. At high pressues the Kinetic energy and thus the movement of the molecules is to great to predict

d. The water in the beaker is at a lower temperature than the water vapor in the air. melting ice is an endothermic process and heat is drawn from the air. As water ~~or~~ vapor cools it goes from the gas to liquid phase and condenses

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