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McCord CH302

unique: 50015

MWF 2pm - 3pm

Exam 1

Fall 2018

Sep 19, 2018

Wednesday 7:30 - 9:00 PM

BUR 106

Remember to refer to the Periodic Table handout that is separate from this exam copy.

NOTE: Please keep this exam copy intact (all pages still stapled - including this cover page). You must turn in ALL the materials that were distributed. This means that you turn in your exam copy (name and signature included), bubble sheet, periodic table handout, and all scratch paper. Please also have your UT ID card ready to show as well.

This print-out should have 20 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

001 5.0 points

A 335 g scoop of ice at −15°C is added to 836 g of hot water at 70°C in an insulated container. All the ice melts and the temperature reaches equilibrium. What is the final temperature inside the container?

1. 17°C

2. 51°C

3. 22°C

4. 28°C

5. 13°C

6. 25°C **correct**

7. 39°C

8. 30°C

9. 45°C

10. 34°C

Explanation:

heat the ice to 0° water.

335(2.09)(15)+335(334) = 12239 J

cool water down to 0° water

836(4.184)70 = 244848 J

take the difference

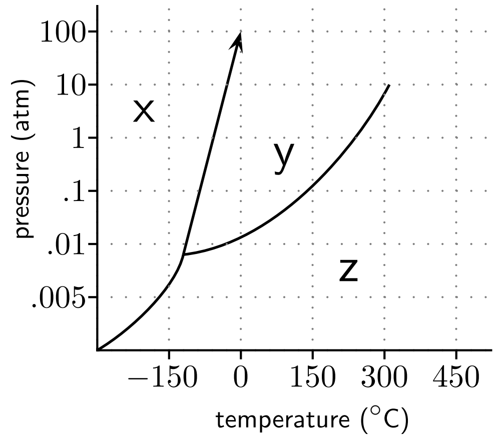
244848 - 12239 = 122456 J of heat to apply to the now 1171 g of 0° water.

$\Delta T = 122456/(4.184 \cdot 1171) = 25.0$°C

$T_{\text{final}} = 0 + \Delta T = 25$°C

002 (part 1 of 3) 5.0 points

Refer to the following phase diagram for this question and the next two questions.



What is the normal boiling point of this substance?

1. 308 °C

2. 240 °C **correct**

3. 130 °C

4. −90 °C

5. −60 °C

6. 200 °C

7. 278 °C

Explanation:

Following the horizontal line at 1 atm, the liquid/gas line crosses it at 240 °C.

003 (part 2 of 3) 5.0 points

Refer to the phase diagram in part 1. What is the critical temperature for this substance?

1. 308 °C **correct**

2. −90 °C

3. −60 °C

4. 200 °C

5. 278 °C

6. 130 °C

7. 240 °C

Explanation:
The critical point is at the end of the line between y and z. It ends at 308 °C.

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004 (part 3 of 3) 5.0 points

Refer once again to the phase diagram in part 1. Which phase has the lowest free energy for this substance at 0.01 atm and 60 °C?

1. liquid

2. all have equal free energy

3. gas **correct**

4. solid

Explanation:
Area x represents the solid phase, area y the liquid phase, and area z the gas phase. As the intersection of 0.01 atm and 60 °C is in area z, the gas phase is the most stable at these conditions, meaning the gas phase has the lowest free energy at these conditions.

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005 5.0 points

Hummingbird food is a sugar solution, made as follows: 1 cup water plus 1/4 cup sugar (sucrose, 342.3 g/mol). What is the molality of sugar in hummingbird food? Here are some useful conversion factors:
1 cup = 0.2366 L ; 1 cup sugar = 200 g sugar

1. 0.146 m

2. 0.617 m **correct**

3. 0.0118 m

4. 0.000619 m

5. 0.0691 m

Explanation:
1/4 cup sugar = 50 g → /342.3 = 0.146 mol
1 cup H_2O = 0.2366 kg H_2O
$m_{\text{sucrose}} = 0.146/0.2366 = 0.617\ m$

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006 5.0 points

The lattice energy for MX is 455 kJ/mol and it's heat of hydration is −345 kJ/mol. What is the heat of solution for MX?

1. 110 kJ/mol **correct**

2. 800 kJ/mol

3. −800 kJ/mol

4. 151 kJ/mol

5. 133 kJ/mol

6. −110 kJ/mol

7. 89 kJ/mol

Explanation:

$$\Delta H_{\text{soln}} = \Delta H_{\text{LE}} + \Delta H_{\text{hyd}}$$

$$\Delta H_{\text{soln}} = 455 + (-345)$$

$$\Delta H_{\text{soln}} = 110\ \text{kJ/mol}$$

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007 5.0 points

Which of the following substances would you predict might evaporate the fastest?

1. $C_{10}H_{22}$

2. C_6H_{14} **correct**

3. C_8H_{18}

4. $C_{12}H_{24}$

Explanation:
All the listed molecules are nonpolar hydrocarbons; therefore the dominant intermolecular force that exists in the condensed phase of all listed molecules is dispersion forces. Therefore, the molecule with the least number of atoms and the lowest molecular weight would have the lowest dispersion forces, and therefore would evaporate the easiest.

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008 5.0 points

The vapor pressure of all liquids

1. is the same at their freezing points.

2. decreases with the increasing volume of the container.

3. increases with temperature. **correct**

4. is the same at 100°C.

5. increases with volume of liquid present.

Explanation:
As temperature (kinetic energy) increases, rate of evaporization increases and rate of condensation decreases; therefore, vapor pressure will increase with increasing temperature.

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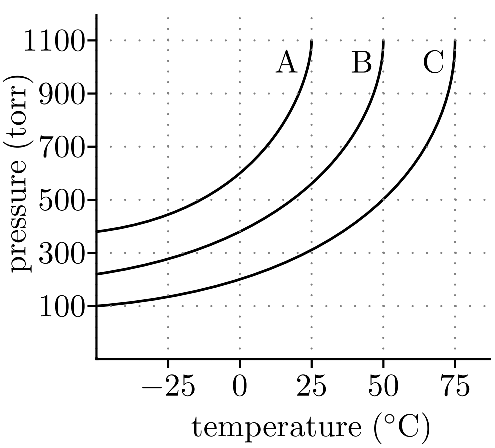
009 (part 1 of 2) 5.0 points
The following is the plot of vapor pressure vs temperature for three substances, A, B, and C.



Which, if any, of these substances would be a gas at SATP?

1. A **correct**

2. A and C

3. A and B

4. B

5. none

6. B and C

7. all 3 are gases

8. C

Explanation:
Only substance A has a vapor pressure greater than 1 bar (750 torr) at 25°C.

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010 (part 2 of 2) 5.0 points
Which ones are gases at STP?

1. A

2. C

3. A and B

4. B and C

5. A and C

6. B

7. none **correct**

8. all 3 are gases

Explanation:
At 0°C all the substances have vapor pressures below 760 torr and are therefore liquids. None are gases at STP.

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011 5.0 points
Estimate the enthalpy of vaporization of CCl_4 given that at 25°C and 58°C its vapor pressure is 107 and 405 torr, respectively. Assume that the enthalpy of vaporization is independent of the temperature.

1. 142 kJ·mol^{-1}

2. 33.1 kJ·mol^{-1} **correct**

3. 48.6 kJ· mol^{-1}

4. 3.98 kJ·mol^{-1}

5. 486 J·mol^{-1}

Explanation:
$T_1 = 25°\mathrm{C} + 273.15 = 298.15$ K

$P_1 = 107$ torr
$T_2 = 58°\text{C} + 273.15 = 331.15$ K
$P_2 = 405$ torr

Using the Clausius-Clapeyron equation,

$$\ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H^\circ_{\text{vap}}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$$\Delta H^0_{\text{vap}} = \frac{R \ln\left(\frac{P_2}{P_1}\right)}{\frac{1}{T_1} + \frac{1}{T_2}}$$

$$= \frac{8.314 \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}}{\frac{1}{298.15 \text{ K}} - \frac{1}{331.15 \text{ K}}} \times \ln\left(\frac{405 \text{ torr}}{107 \text{ torr}}\right)$$

$$= 33109.5 \text{ J} \cdot \text{mol}^{-1}$$

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012 5.0 points

The vapor pressure of a pure liquid depends on which of the following

I. the volume of the liquid
II. the volume of the gas
III. the surface area of the liquid
IV. the temperature

1. only III

2. I and II

3. only II

4. only I

5. III and IV

6. all of them

7. only IV **correct**

Explanation:

The vapor pressure of a given liquid depends only the temperature

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013 5.0 points

Consider an ideal gas dissolving into a liquid. Which of the following is/are true?

I) ΔS is negative for this process.

II) $\Delta H_{\text{solution}}$ is positive for this process.

III) This process only occurs at high enough temperatures.

IV) $\Delta H_{\text{lattice}}$ is equal to zero for the gas.

1. I only

2. I, II, and IV only

3. I and III only

4. I and II only

5. I, III, and IV only

6. I, II, III, and IV

7. I and IV only **correct**

Explanation:

For a gas dissolving in a liquid, ΔS and $\Delta H_{\text{solution}}$ are negative. For ΔG to be negative, the temperature must be relatively low. Because we are dealing with an ideal gas, which has no intermolecular forces, $\Delta H_{\text{lattice}}$ is equal to zero.

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014 5.0 points

As the temperature of water sample is decreased, we expect to see a(n) (decrease/increase) in the solubility of (all/some) dissolved gases.

1. increase, all **correct**

2. increase, some

3. decrease, some

4. decrease, all

Explanation:

Because the dissolution of most all gases is an exothermic process, Le Chatelier's principle suggests that all gases will become more soluble as the temperature of the solvent is lowered.

015 5.0 points

Which of the following statements about colligative properties of aqueous solutions is FALSE?

1. Osmosis is a colligative property.

2. Colligative properties only depend on the number of solute particles present in solution.

3. The higher the concentration of solute in the solution, the higher the vapor pressure of the solvent. **correct**

4. For a given solution, the freezing point will be lowered more than the boiling point will be raised.

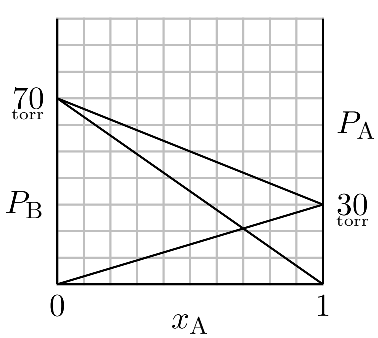
Explanation:

Colligative properties, which include osmosis, vapor pressure lowering, melting and boiling point elevations, depend only on the number of solute particles present in solution, not on their properties. The effect on the melting point of a given solution is more than the effect on its boiling point.

With a higher concentration of non-volatile solute the concentration of the solvent in the solution is lower, causing the vapor pressure of the solution to be lower.

016 5.0 points

Consider the following vapor pressure diagram for a binary liquid containing solvents A and B.



If 3 moles of A and 2 moles of B are mixed, what is the vapor pressure of the solution?

1. 46 torr **correct**

2. 28 torr

3. 50 torr

4. 62 torr

5. 54 torr

6. 38 torr

Explanation:

The mole fraction of A is

$$x_A = \frac{\text{mol A}}{\text{total mol}} = \frac{3}{2+3} = 0.6$$

making the mole fraction of B equal to 0.4

The 0.6 x_A line intersects the overall vapor pressure line at 46 torr.

Or you can calculate it...

$P = (.6)(30) + (.4)70 = 46$ torr

017 5.0 points

What is the boiling point elevation of a solution of Na_2SO_4 (142.1 g/mol, complete dissociation) made by dissolving 10.0 g of Na_2SO_4 into 250 g water ($K_b = 0.512°C/m$)?

1. 0.288°C

2. 0.108°C

3. 0.144°C

4. 0.576°C

5. 0.363°C

6. 0.432°C **correct**

Explanation:

$m_{Na_2SO_4} = 10.0$ g $\qquad m_{water} = 250$ g

$MW_{Na_2SO_4} = 142.1$ g/mol

$$m = \frac{\frac{10}{142.1}}{0.25} = 0.2815\ m$$

$$m(\text{ideal}) = (3)(0.2815) = 0.844\ m$$

because 3 ions formed. Thus

$$\Delta T = (0.512)(0.844\ m) = 0.432°C$$

018 5.0 points

When 20.0 grams of an unknown compound are dissolved in 500 grams of benzene, the freezing point of the resulting solution is 3.77°C. The freezing point of pure benzene is 5.48°C, and its freezing point depression constant is $K_f = 5.12$°C/molality. What is the molecular weight of the unknown compound?

1. 120 grams/mole **correct**

2. 100 grams/mole

3. 80.0 grams/mole

4. 140 grams/mole

5. 160 grams/mole

Explanation:

$m_{\text{unknown}} = 20$ g $\qquad T_f = 3.77$°C

$m_{\text{benzene}} = 500$ g $\qquad T_f^0 = 5.7$°C

$\Delta T_f = K_m$ where ΔT_f is the freezing point (FP) depression, K_f is the FP depression constant, and m is the molarity.

$$\frac{\text{mol solute}}{\text{kg solvent}} = \frac{20.0(\text{g/MW})}{0.500\text{ kg}}$$

$$\Delta T_f = K_f\, m$$

$$m = \frac{\Delta T_f}{K_f}$$

$$\frac{20.0(\text{g/MW})}{0.500\text{ kg}} = \frac{1.71°\text{C}}{5.12°\text{C}/(\text{mol/kg})}$$

$$\begin{aligned}\text{MW} &= \frac{20.0\text{ g}(5.12°\text{C}\cdot\text{kg/mol})}{1.71°\text{C}\times 0.0500\text{ kg}}\\ &= 120\text{ g/mol}\end{aligned}$$

$\Delta T_f = 5.48 - 3.77 = 1.71$°C

$K_f = 5.12$°C/molarity = moles/kg solute

019 5.0 points

What is the osmotic pressure of a solution that contains 4.56 $\times 10^{-3}$ moles of lactose in 100 mL of solution at 25°C?

1. 1053 torr

2. 71 torr

3. 848 torr **correct**

4. 536 torr

5. 113 torr

Explanation:

$n = 4.56 \times 10^{-3}$ mol $\qquad V = 100$ mL

$T = 25°\text{C} + 273.15 = 298.15$ K

$$\begin{aligned}M &= \left(\frac{456\times 10^{-3}\text{ mol}}{100\text{ mL}}\right)\left(\frac{1000\text{ mL}}{\text{L}}\right)\\ &= 4.56\times 10^{-2}\,\frac{\text{mol}}{\text{L}}\end{aligned}$$

Osmotic pressure

$$\begin{aligned}\pi &= M\,R\,T\\ &= \left(4.56\times 10^{-2}\text{ mol/L}\right)\\ &\quad\times\left(62.36\,\frac{\text{L}\cdot\text{torr}}{\text{K}\cdot\text{mol}}\right)(298.15\text{ K})\\ &= 847.8\text{ torr}\end{aligned}$$

020 5.0 points

Which of the following solutes is likely to be most soluble in water?

1. ethanol (CH_3CH_2OH) **correct**

2. carbon tetrachloride (CCl_4)

3. Br_2

4. CS_2

Explanation: