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McCord CH302

unique: 49175 and 49190

Exam 1

Feb 13, 2019

Wednesday 7:30 - 9:00 PM

A-L in UTC 2.112A

M-Z In 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.

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001 5.0 points

A 19.7 g sample of an unknown salt (formula = MX_2) is dissolved in 249.4 mL water. The boiling point of water in this solution is 100.657 °C. What is the molecular weight of the unknown salt?

1. 129.8 g/mol

2. 61.6 g/mol

3. 55.4 g/mol

4. 185 g/mol **correct**

5. 46.1 g/mol

Explanation:
Using the equation $\Delta T = i \cdot k_b \cdot m$, you can solve for the molality of the unknown salt in water.

$$m = \frac{0.657}{3 \cdot 0.512}$$
$$m = 0.4277 \text{ mol kg}^{-1}$$

Then convert molality into moles by multiplying by the mass of the H_2O solvent:

$$\frac{0.4277 \text{ mol}}{\text{kg}} \left(\frac{0.2494 \text{ kg}}{1} \right) = 0.1067 \text{ mol}$$

Finally, we can use the gram quantity and number of moles to solve for the molecular weight of the salt:

$$\frac{19.7 \text{ g}}{0.1067 \text{ mol}} = 185 \text{ g/mol}$$

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002 5.0 points

Consider two ionic compounds that dissolve fully in water at room temperature. You run an experiment and determine the following:

1. Compound A has stronger solute-solute attractions than solute-solvent attractions.
2. Compound B has stronger solute-solvent attractions than solute-solute attractions.

Which of the following best describes the $\Delta H_{\text{solution}}$ for Compound A and Compound B, respectively?

1. Endothermic, exothermic **correct**

2. Exothermic, exothermic

3. Exothermic, endothermic

4. Both processes are endothermic, but Compound A is more endothermic

5. Both processes are exothermic, but Compound B is more exothermic

6. Both processes are equally exothermic

Explanation:
The enthalpy of solution is the sum of enthalpy of lattice (positive) and enthalpy of solvation (negative). If $\Delta H_{\text{lattice}} > \Delta H_{\text{solvation}}$, the process will be endothermic. If $\Delta H_{\text{lattice}} < \Delta H_{\text{solvation}}$, the process will be exothermic. Therefore, we see here that Compound A is endothermic and compound B is exothermic.

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003 5.0 points

Consider the following generic gas phase reaction.

$$X_2(g) + 3Y_2(g) \rightleftharpoons 2XY_3(g)$$

The value of K_p for this reaction is 107. Calculate the equilibrium partial pressure of gas Y_2 if the equilibrium partial pressures of XY_3 is 0.50 atm and X_2 is 0.15 atm?

1. 0.031 atm

2. 0.18 atm

3. 0.42 atm

4. 0.33 atm

5. 5.6 atm

6. 0.016 atm

7. 0.25 atm **correct**

Explanation:
$107 = K_\text{p}$

$107 = \frac{(P_{\text{XY}_3})^2}{(P_{\text{X}_2})(P_{\text{Y}_2})^3} = \frac{(0.50)^2}{(0.15)(P_{\text{Y}_2})^3}$

$\text{P}_{\text{Y}_2} = 0.25$ atm

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004 5.0 points

Write the equilibrium constant for the following reaction.

$$\text{H}_2(\text{g}) + \text{Br}_2(\ell) \rightleftharpoons 2\text{HBr(g)}$$

1. $K_p = \frac{P_{\text{HBr}}}{P_{\text{H}_2}}$

2. $K_p = \frac{P^2_{\text{HBr}}}{P_{\text{H}_2}}$
correct

3. $K_p = \frac{P^2_{\text{HBr}}}{P_{\text{H}_2}[\text{Br}_2]}$

4. $K_p = \frac{P_{\text{H}_2}}{P^2_{\text{HBr}}}$

5. $K_p = \frac{P^2_{\text{HBr}}}{P_{\text{H}_2}P_{\text{Br}_2}}$

Explanation:
Take the concentration of the products raised to the power of their coefficients divided by the reactants raised to the power of their coefficients, ignoring any liquid or solids.

$$K_p = \frac{\text{P}^2_{\text{HBr}}}{\text{P}_{\text{H}_2}}$$

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005 5.0 points

Isocarboxazid (MW = 231.25 g/mol) is an organic monoamine oxidase inhibitor used to treat depression disorders. 38.00 grams of isocarboxazid are added to water to make a 350 mL aqueous solution. What is the osmotic pressure exerted by this solution across a semi-permeable membrane at 37°C?

1. 1.43 atm

2. 12.10 atm

3. 329.6 atm

4. 23.90 atm

5. 144.4 atm

6. 11.95 atm **correct**

Explanation:
Osmotic pressure is calculated using the formula:

$$\Pi = MRT$$

$R = 0.08206\,\text{L}\cdot\text{atm/mol}\cdot\text{K}$

$T = 310.15\,\text{K}$

Solving first for molarity:

$$M = \frac{(38.0\,\text{g})(\frac{\text{mol}}{231.25\,\text{g}})}{0.350\,\text{L}} = 0.4695\,\text{M}$$

$$11.95\,\text{atm} = (0.4695)(0.08206)(310.15)$$

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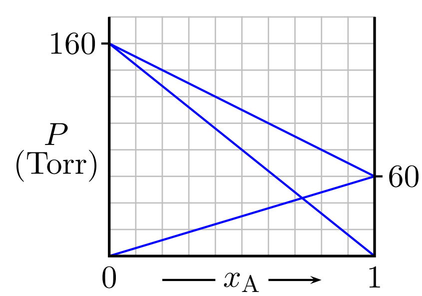
006 5.0 points

A and B are mildly volatile solvents. A mixture is made by combining 2 moles of A with 3 moles of B. Interpret the diagram below to determine the vapor pressure of this mixture.



1. 110 Torr

2. 100 Torr

3. 140 Torr

4. 80 Torr

5. 70 Torr

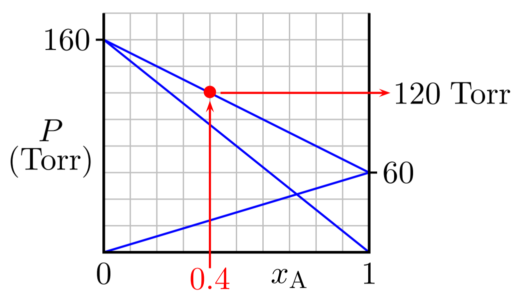
6. 120 Torr **correct**

7. 90 Torr

8. 150 Torr

9. 130 Torr

Explanation:
Mixing 2 mol A and 3 mol B is a 2/5 mol fraction of A, or 0.4. Each vertical grid line is 0.1 mol fraction units, so counting 4 over we have the right line. Following it all the way up to the mixture vapor pressure we get 120 Torr (see diagram below). Alternatively, you can use Raoult's Law and Dalton's law to take the sum of partial pressures, which is simply 120 torr = 0.4(60) + 0.6(160)



007 5.0 points

A sample of 44.1 g of *para*-dichlorobenzene ($C_6H_4Cl_2$ 147.0 g/mol) is dissolved into 350 mL of hexane (C_6H_{14}, 86.18 g/mol, density 0.661 g/mL). What is the molality of this solution?

1. 0.101 m

2. 0.567 m

3. 1.17 m

4. 0.857 m

5. 1.30 m **correct**

Explanation:
Molality is defined as the moles of solute divided by kg solvent. Solve first for the mass of solvent:

$$350\,\text{mL} \times \frac{0.661\,\text{g}}{\text{mL}} = 231.35\,\text{g}$$

mol of solute = 44.1/147 = 0.300 mol solute
Next take the ratio of moles solute per kg solvent:

$$\frac{0.300\,\text{mol}}{0.23135\,\text{kg}} = 1.2967 = 1.30\,m$$

008 5.0 points

Calculate the number of moles of oxygen that will dissolve in 45 L of water at 20°C if the partial pressure of oxygen is 0.21 atm. Henry's constant for oxygen is 0.0013 M/atm.

1. 0.0062 mol

2. 0.0013 mol

3. 0.012 mol **correct**

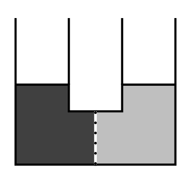
4. 0.00027 mol

5. 0.28 mol

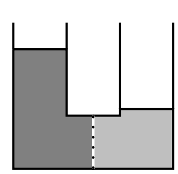
Explanation:

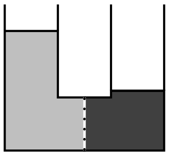
009 5.0 points

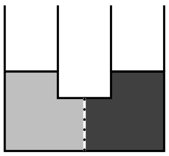
The following diagram shows a solution on the left (dark shade) and just the solvent on the right (light shade) separated by a semipermeable membrane.

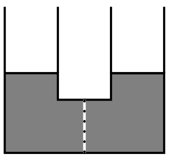


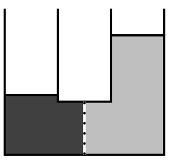
Which diagram best represents the final state of this system after equilibrium is achieved?

1.  **correct**

2. 

3. 

4. 

5. 

Explanation:
Only the solvent goes through the membrane thus increasing the volume on the solution side and decreasing volume on the solvent side. The solution side is therefore diluted slightly and the shade is lightened somewhat. The solute itself (the darker color) cannot pass through the membrane so the right side MUST also stay the same color of pure solvent (the lighest shade shown).

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010 5.0 points

Consider the following substances: acetic acid (CH_3COOH), propane (C_3H_8), and acetone (CH_3COCH_3). The boiling points (in no particular order) are −42°C, 56°C, and 118°C. The vapor pressures (in no particular order) are 225 Torr, 15 Torr, and 6400 Torr. What is the boiling point and vapor pressure for acetic acid?

1. 118°C, 15 Torr **correct**

2. −42°C, 6400 Torr

3. −42°C, 15 Torr

4. 118°C, 6400 Torr

5. 56°C, 225 Torr

Explanation:
Of the three compounds listed, acetic acid has the strongest IMFs (hydrogen bond). This will correspond to the lowest vapor pressure and highest boiling point: 15 Torr and 118°C.

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011 5.0 points

A reaction has a negative change in entropy. This reaction can only be spontaneous if...

1. None of these choices are correct because a reaction with a negative change in entropy can never be spontaneous

2. heat is released at a sufficiently low temperature **correct**

3. heat is absorbed by the system at any temperature

4. heat is released at any temperature

5. heat is absorbed at a sufficiently high temperature

Explanation:
A reaction must have at least one favorable term between entropy and enthalpy in order to be spontaneous. The negative entropy term is unfavorable, meaning the reaction must be exothermic (heat is released). Moreover, the reaction will only have a negative free energy change if the temperature is small enough. Conceptually, this is because the energy must be able to flow from the system to the low temperature surroundings.

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012 5.0 points

Which of the following solutions have a boiling point equal to a 1.12 m $Fe(NO_3)_3$ aqueous solution? Assume all solutions are aqueous and all salts dissolve completely.

I. 4.48 m glucose

II. 1.12 m $Cu(NO_3)_2$

III. 2.24 m KNO_3

IV. 2.24 m $CaCl_2$

1. I, II, III, and IV

2. I and III only **correct**

3. I only

4. I and II only

5. II and IV only

6. II only

Explanation:
Using the equation $\Delta T = i \cdot k_f \cdot m$, you can determine that the aqueous solution that has the same freezing point as $Fe(NO_3)_3$ ($i = 4$) will have $4.48 = i \cdot m$. Simply multiply each molality by the compound's van't Hoff Factor (i) to determine the effective concentration. This corresponds to the glucose and KNO_3 solutions.

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013 5.0 points

Two liquids mix spontaneously at 180°C. At room tempearture, the liquids separate into two layers instead of mixing. Which of the following is true for the process of mixing at room temperature?

1. $\Delta H < T\Delta S$

2. $\Delta G < 0$

3. $\Delta S < 0$

4. $\Delta H < 0$

5. $\Delta H > T\Delta S$ **correct**

Explanation:
The mixing of these liquids is temperature dependent and spontaneous only at high temperatures. This means that it must be endothermic and a positive entropy change. The entropy change drives the process. If the entropy term is smaller than the enthalpy term, it will be non-spontaneous. At room temperature, $\Delta H > T\Delta S$.

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014 5.0 points

A given reaction is found to have an equilibrium constant $K_\text{p} = 2.29$. What is the equilibrium constant for the REVERSE reaction?

1. 0.326

2. -2.29

3. 0.897

4. More information is needed.

5. 0.437 **correct**

6. 2.29

Explanation:
The equilibrium constant of the reverse reaction is the inverse of the forward reaction's equilibrium constant (products of the forward rxn are reactants of the reverse, and reactants of the forward are products of the reverse).

$$K_\text{p,reverse} = \frac{1}{2.29} = 0.437$$

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015 5.0 points

Consider the following reactions at 550 K:

Reaction	K_p
$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$	9.1×10^{-3}
$2HBr(g) \rightleftharpoons H_2(g) + Br_2(g)$	1.1×10^{-11}
$2HCl(g) \rightleftharpoons H_2(g) + Cl_2(g)$	2.6×10^{-19}

Beginning with equal starting conditions, which compound will produce the greatest amount of hydrogen gas?

1. Each reaction will produce the same quantity of hydrogen gas

2. HBr

3. HI **correct**

4. HCl

Explanation:
Because the reactions have the same product/reactant ratio and the same starting conditions, the largest K_p value will give you the most hydrogen gas product. This corresponds to the HI reaction.

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016 5.0 points

The enthalpy of vaporization of a liquid is measured to be about 28.4 kJ/mol and its normal boiling point is 128°C. At what temperature is the partial pressure of this substance 1180 torr?

1. 162°C

2. 181°C

3. -281°C

4. -381°C

5. 176°C

6. -7.92°C

7. 150°C **correct**

Explanation:
Here we use the Clausius-Clapeyron equation to solve for T_1:

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

$P_1 = 1180$ torr

$P_2 = 760$ torr

$T_2 = 124°\text{C} + 273 = 401$ K

$\Delta H_{\text{vap}} = 28.4$ kJ/mol

$R = 0.008314$ kJ/mol K

And...

$T_1 = 150°\text{C}$

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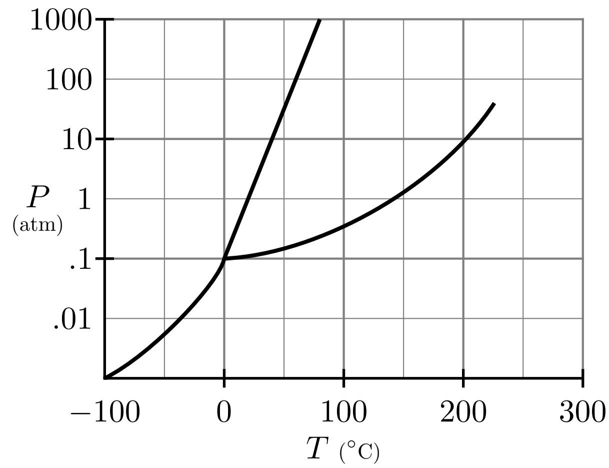
017 (part 1 of 2) 5.0 points

Use the following phase diagram for the next two questions.



What is the normal melting point for this substance? Note: the vertical axis is logarithmic in scale.

1. 0°C

2. 150°C

3. 45°C

4. 20°C **correct**

5. 75°C

6. 120°C

Explanation:
The normal melting point is the point on the line where the solid and liquid phases coincide at 1 atm. This is found just less than halfway between the 0 and 50°C gridlines.

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018 (part 2 of 2) 5.0 points

A sample of this substance is held at 0.1 atm and −50°C. The sample is pressurized to 3 atm and then heated to 250°C. In total, what phase transitions occurred?

1. melting and freezing

2. sublimation only

3. melting and boiling **correct**

4. sublimation and condensation

5. melting and condensation

Explanation:
Pressurizing from 0.1 atm to 3 atm does not result in a change of phase. However, heating to 250°C results in the melting of the solid followed by the vaporization of the liquid.

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019 5.0 points

Which of the following statements is/are true at the normal boiling point for a given substance?

I. The vapor pressure of the substance equals the applied pressure

II. The free energy of the gas phase is equal to the free energy of the liquid phase

III. The free energy of the solid, liquid, and gas phases are all equal

IV. $\Delta H^\circ_{\text{vap}} = 0$

1. I, II, and IV only

2. I and IV only

3. I and II only **correct**

4. I only

5. II only

6. I and III only

Explanation:
At the normal boiling point, the vapor pressure of the substance equals atmospheric pressure. The free energy of the gas phase and liquid phase (but not the solid phase) are equal. $\Delta H^\circ_{\text{vap}} > 0$

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020 5.0 points

You measure the boiling points for three unique aqueous solutions with unknown concentrations. The data is shown below:

KCl solution, $T_b = 100.379$°C

$CaCl_2$ solution, $T_b = 100.113$°C

$C_6H_{12}O_6$ solution, $T_b = 100.217$°C

Which of these solutions is expected to have the lowest freezing point?

1. KCl solution **correct**

2. The freezing point will be equal for all solutions

3. $CaCl_2$ solution

4. $C_6H_{12}O_6$ solution

Explanation:
The dissolution of a substance in water will increase the stability of the liquid phase. This raises the boiling point, lowers the freezing point, and decreases the vapor pressure. The solution with the highest boiling point will have the lowest freezing point and lowest vapor pressure. This corresponds to the KCl solution.