

004

version

last name

first name

signature

practice **Exam 1** practice

MWF Classes · Spring 2016

REMEMBER: Bubble in ALL Bubblesheet information!

This includes your first and last name, your UTEID, and your version number.

Please refer to the back of the bubble sheet for more info.

$$R = 8.314 \text{ J/mol}\cdot\text{K}$$

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

$$R = 62.36 \text{ L torr/mol}\cdot\text{K}$$

$$1 \text{ atm} = 1.01325 \times 10^5 \text{ Pa}$$

$$1 \text{ atm} = 760 \text{ torr}$$

$$1 \text{ atm} = 14.7 \text{ psi}$$

$$PV = nRT$$

$$q = m \cdot C_s \cdot \Delta T \quad q = m \cdot \Delta H_{\text{change}}$$

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

$$\Delta H_{\text{solution}} = \Delta H_{\text{lattice}} + \Delta H_{\text{hydration}}$$

$$P_A = \chi_A \cdot P_A^\circ$$

water data

$$K_f = 1.86 \text{ }^\circ\text{C}/m$$

$$K_b = 0.512 \text{ }^\circ\text{C}/m$$

$$C_{s,\text{ice}} = 2.09 \text{ J/g K}$$

$$C_{s,\text{water}} = 4.184 \text{ J/g K}$$

$$C_{s,\text{steam}} = 2.03 \text{ J/g K}$$

$$\Delta H_{\text{fus}} = 334 \text{ J/g}$$

$$\Delta H_{\text{vap}} = 2260 \text{ J/g}$$

$$\Delta T_f = i \cdot K_f \cdot m \quad \Delta T_b = i \cdot K_b \cdot m$$

$$\Pi = i \cdot MRT$$

$$G = H - TS \quad \Delta G = \Delta H - T\Delta S$$

NOTE: Please keep your Exam copy intact (all pages still stapled). You must turn in your exam copy, plus your bubble sheet, and any scratch paper.

This print-out should have 25 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

001 4.0 points

Identify the spectator ion(s) in the equation
 $\text{CaCl}_2(\text{aq}) + \text{Na}_2\text{CO}_3(\text{aq}) \rightarrow \text{CaCO}_3(\text{s}) + 2\text{NaCl}(\text{aq})$.

1. Ca^{2+} , Cl^-
2. Na^+ , Cl^- **correct**
3. Na^+ , CO_3^{2-}
4. Ca^{2+} , CO_3^{2-}

Explanation:

Spectator ions are those that do not participate in the reaction nor appear in the net ionic equation. Sodium ions (Na^+), potassium ions (K^+), nitrate (NO_3^-) and chloride (Cl^-) are common spectator ions.

002 4.0 points

Suppose that you wanted to be sure that a metal ion, any metal ion, would dissolve in water.

What salt of the metal ion compound would you choose?

1. the chloride (Cl^-) salt of the metal ion
2. the hydroxide (OH^-) salt of the metal ion
3. the carbonate (CO_3^{2-}) salt of the metal ion
4. the nitrate (NO_3^-) salt of the metal ion **correct**

Explanation:

Nitrate (NO_3^-) salts of any metal are always soluble.

003 4.0 points

A solution containing all of the solute that a solvent can dissolve at a certain temperature

and pressure is called

1. a concentrated solution.
2. an unsaturated solution.
3. a saturated solution. **correct**
4. a supersaturated solution.

Explanation:

004 4.0 points

Consider a 200 g block of ice at standard pressure. If it is initially at -23°C and is heated until it is steam at 148°C , how much total heat was added to the sample of water? Use the following thermodynamic values for your calculation:

$$\begin{aligned} c_{\text{ice}} &= 2.09 \text{ J} \cdot \text{g}^{-1} \cdot \text{K}^{-1} \\ c_{\text{water}} &= 4.184 \text{ J} \cdot \text{g}^{-1} \cdot \text{K}^{-1} \\ c_{\text{steam}} &= 2.03 \text{ J} \cdot \text{g}^{-1} \cdot \text{K}^{-1} \\ \Delta H_{\text{vap}} &= 2260 \text{ J} \cdot \text{g}^{-1} \\ \Delta H_{\text{fus}} &= 334 \text{ J} \cdot \text{g}^{-1} \end{aligned}$$

1. 632 kJ **correct**
2. 565 kJ
3. 29.1 kJ
4. 548 kJ
5. 822 kJ

Explanation:

$$\begin{aligned} \Delta T_1 &= 0^\circ\text{C} - (-23^\circ\text{C}) = 23^\circ\text{C} \\ \Delta T_2 &= 100^\circ\text{C} \\ \Delta T_3 &= 148^\circ\text{C} - 100^\circ\text{C} = 48^\circ\text{C} \\ m &= 200 \text{ g} \\ q &= 632 \text{ kJ} \end{aligned}$$

005 4.0 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:

$$T_1 = 25^\circ\text{C} + 273.15 = 298.15\text{ K}$$

$$P_1 = 107\text{ torr}$$

$$T_2 = 58^\circ\text{C} + 273.15 = 331.15\text{ K}$$

$$P_2 = 405\text{ torr}$$

Using the Clausius-Clapeyron equation,

$$\begin{aligned}\ln\left(\frac{P_2}{P_1}\right) &= \frac{\Delta H_{\text{vap}}^\circ}{R} \left(\frac{1}{T_1} - \frac{1}{T_2}\right) \\ \Delta H_{\text{vap}}^0 &= \frac{R \ln\left(\frac{P_2}{P_1}\right)}{\frac{1}{T_1} - \frac{1}{T_2}} \\ &= \frac{8.314\text{ J} \cdot \text{mol}^{-1} \cdot \text{K}}{\frac{1}{298.15\text{ K}} - \frac{1}{331.15\text{ K}}} \times \ln\left(\frac{405\text{ torr}}{107\text{ torr}}\right) \\ &= 33109.5\text{ J} \cdot \text{mol}^{-1}\end{aligned}$$

006 4.0 points

On a hiking expedition with Bear Grylls, you ‘accidentally’ end up in a huge chasm 2 km below sea level. Bear, being the resourceful TV star that he is, builds a fire and promptly starts to heat some water to cook the local snake for dinner. At what temperature do you expect Bear’s water to boil?

1. At 100°C exactly
2. Lower than 100°C
3. Higher than 100°C **correct**
4. None of these; Bear Grylls eats his food raw!

Explanation:

At sea level, the pressure is 1 atm (760 torr). As you decrease elevation, pressure increases, raising the boiling point of water.

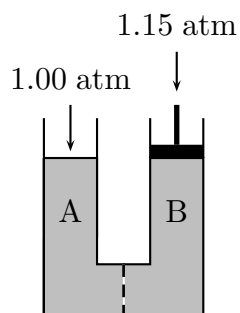
007 4.0 points

Pure water is saturated with PbCl₂. In this saturated solution

1. $2[\text{Cl}^-] = [\text{Pb}^{2+}]$.
2. $K_{\text{sp}} = [\text{Pb}^{2+}]$.
3. $[\text{Pb}^{2+}][\text{Cl}^-] = K_{\text{sp}}$.
4. $[\text{Pb}^{2+}] = 0.5[\text{Cl}^-]$ **correct**
5. $[\text{Pb}^{2+}] = [\text{Cl}^-]$.

Explanation:**008 4.0 points**

Water from a local stream is added to one side of the U-tube shown below. Pure water is placed in the tube on the other side of the semipermeable membrane. With the left side open to barometric pressure of 1.0 atm and 1.15 atm applied to the right side, the two liquids do not move.



In which half of the U-tube is the pure water located?

1. Not enough information is given.
2. A **correct**
3. B

Explanation:

009 4.0 points

The vapor pressure of pure CH_2Cl_2 (with molecular weight 85 g/mol) is 133 torr at 0°C and the vapor pressure of pure CH_2Br_2 (with molecular weight 174 g/mol) is 11 torr at the same temperature. What is the total vapor pressure at 0°C of a solution prepared from equal masses of these two substances?

1. 93 torr **correct**

2. 44 torr

3. 89 torr

4. 124 torr

5. 144 torr

6. 72 torr

7. 3.6 torr

8. 105 torr

9. 7.4 torr

Explanation:

For CH_2Cl_2 ,
 $P^0 = 133$ torr MW = 85 g/mol

For CH_2Br_2 ,
 $P^0 = 11$ torr MW = 174 g/mol

The mole fractions are

$$X_{\text{CH}_2\text{Cl}_2} = \frac{n_{\text{CH}_2\text{Cl}_2}}{n_{\text{CH}_2\text{Cl}_2} + n_{\text{CH}_2\text{Br}_2}} = \frac{\text{g}/85}{\text{g}/85 + \text{g}/174} = 0.672$$

$$X_{\text{CH}_2\text{Br}_2} = \frac{n_{\text{CH}_2\text{Br}_2}}{n_{\text{CH}_2\text{Br}_2} + n_{\text{CH}_2\text{Cl}_2}} = \frac{\text{g}/174}{\text{g}/174 + \text{g}/85} = 0.328$$

Thus

$$\begin{aligned} P_{\text{solution}} &= P_{\text{CH}_2\text{Cl}_2} + P_{\text{CH}_2\text{Br}_2} \\ &= X_{\text{CH}_2\text{Cl}_2} P_{\text{CH}_2\text{Cl}_2}^0 \\ &\quad + X_{\text{CH}_2\text{Br}_2} P_{\text{CH}_2\text{Br}_2}^0 \end{aligned}$$

$$\begin{aligned} &= (0.672)(133 \text{ torr}) \\ &\quad + (0.328)(11 \text{ torr}) \\ &= 93.0 \text{ torr} \end{aligned}$$

010 4.0 points

Which of the following salts would have the greatest molar solubility?

1. CdS $K_{sp} = 3.60 \times 10^{-29}$ 2. Cu_2S $K_{sp} = 2.00 \times 10^{-47}$ 3. $\text{Al}(\text{OH})_3$ $K_{sp} = 1.90 \times 10^{-33}$ 4. PbCrO_4 $K_{sp} = 1.77 \times 10^{-14}$ **correct****Explanation:**

Lead chromate is a salt composed of only two ions and thus its molar solubility is equal to the square root of its K_{sp} . The best approximation is therefore $(10^{-14})^{1/2} = 10^{-7}$.

011 4.0 points

In general, decreasing the temperature makes which phase transitions more likely to occur?

1. evaporation, deposition, freezing

2. evaporation, fusion, sublimation

3. sublimation, condensation, freezing

4. condensation, fusion, deposition

5. condensation, freezing, deposition **correct****Explanation:**

Phase changes are equilibrium processes and are thus temperature dependent. Also, the ΔH and ΔS always have the same sign. Lowering the temperature makes exothermic phase transitions more likely - freezing, condensation and deposition.

012 4.0 points

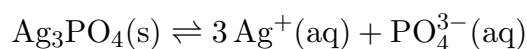
What is K_{sp} for Ag_3PO_4 , if its molar solubility is 2.7×10^{-6} mol/L?

1. 5.3×10^{-23}
2. 4.8×10^{-22}
3. 7.3×10^{-12}
4. 5.3×10^{-16}
5. 1.7×10^{-14}
6. 2.0×10^{-17}
7. 1.4×10^{-21} **correct**

Explanation:

$$S = 2.7 \times 10^{-6} \text{ mol/L}$$

The solubility equilibrium is



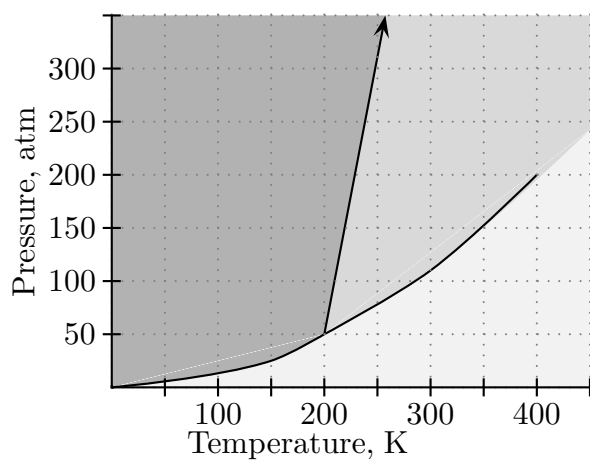
$$[\text{Ag}^+] = 3S = 8.1 \times 10^{-6} \text{ mol/L}$$

$$[\text{PO}_4^{3-}] = S = 2.7 \times 10^{-6} \text{ mol/L}$$

$$\begin{aligned} K_{\text{sp}} &= [\text{Ag}^+]^3[\text{PO}_4^{3-}] \\ &= (8.1 \times 10^{-6})^3 (2.7 \times 10^{-6}) \\ &= 1.43489 \times 10^{-21} \end{aligned}$$

013 4.0 points

The phase diagram for a pure substance is given below.



The substance is stored in a container at 150 atm at 25°C. Describe what happens if the container is opened at 25°C.

1. The vapor in the container escapes.
 2. The solid in the container sublimates.
 3. The solid in the container melts.
 4. The liquid in the container freezes.
 5. The liquid in the container vaporizes.
- correct**

Explanation:**014 4.0 points**

Nitrogen gas, $\text{N}_2(\text{g})$, has a certain solubility when dissolved in water. In which of the following cases would the solubility of $\text{N}_2(\text{g})$ increase?

- I) changing to a less polar solvent
- II) increasing the amount of solvent
- III) increasing the pressure of $\text{N}_2(\text{g})$

1. II only
2. I only
3. II and III
4. I and III **correct**
5. I and II
6. I, II and III
7. III only

Explanation:

The solubility of a gas is directly proportional to the gas' pressure and inversely proportional to the temperature of the solvent. Considering the principle of like dissolve like, a non-polar species such as $\text{N}_2(\text{g})$ will be more soluble in non-polar solvents. The volume of the solvent does not impact the solubility, which is an intensive property; this is evident when one considers the units of solubility such as grams per liter, etc.

015 4.0 points

What mass of ethylene glycol ((CH₂OH)₂ with molecular weight 62 g/mol) must be added to 1.00 L of H₂O (of mass 1 kg) to lower the freezing point to -5°C ? $K_{\text{f H}_2\text{O}} = 1.86^{\circ}\text{C}/m$.

1. 167 g **correct**
2. 330 g
3. 123 g
4. 25 g
5. 66 g

Explanation:

$\text{MW}_{\text{CH}_2\text{OH}} = 62 \text{ g/mol}$
 $m_{\text{H}_2\text{O}} = 1 \text{ kg}$

$V_{\text{H}_2\text{O}} = 1 \text{ L}$
 $T_{\text{f}} = -5^{\circ}\text{C}$

$$\begin{aligned} T_{\text{f}} &= T_{\text{f}}^0 - \Delta T_{\text{f}} \\ \Delta T_{\text{f}} &= T_{\text{f}}^0 - T_{\text{f}} \\ &= 0.00^{\circ}\text{C} - (-5^{\circ}\text{C}) \\ &= 5^{\circ}\text{C} \end{aligned}$$

$$\begin{aligned} \Delta T_{\text{f}} &= K_{\text{f}} \cdot m \\ m &= \frac{\Delta T_{\text{f}}}{K_{\text{f}}} \\ &= \frac{5^{\circ}\text{C}}{1.86^{\circ}\text{C}/m} = 2.688 m \end{aligned}$$

$$\begin{aligned} m &= \frac{n_{(\text{CH}_2\text{OH})_2}}{\text{kg water}} = \frac{\frac{\text{g}(\text{CH}_2\text{OH})_2}{\text{MW}(\text{CH}_2\text{OH})_2}}{\text{kg water}} \\ &= \frac{\text{g}(\text{CH}_2\text{OH})_2}{m(\text{MW}(\text{CH}_2\text{OH})_2)(\text{kg water})} \\ &= \frac{2.688 \text{ mol}(\text{CH}_2\text{OH})_2}{\text{kg water}} \\ &\quad \times \frac{62.0 \text{ g}(\text{CH}_2\text{OH})_2}{\text{mol}(\text{CH}_2\text{OH})_2} \\ &\quad \times (1 \text{ kg water}) \\ &= 167 \text{ g}(\text{CH}_2\text{OH})_2 \end{aligned}$$

016 4.0 points

Rank the liquids

NH₃, CH₃OH, CH₃CH₂F, CCl₄

by their miscibility in heptane (C₇H₁₆), from most miscible to least.

1. CCl₄ > CH₃CH₂F > CH₃OH > NH₃ **correct**

2. CH₃CH₂F > CCl₄ > CH₃OH > NH₃

3. NH₃ > CH₃OH > CH₃CH₂F > CCl₄

4. CH₃CH₂F > CH₃OH > CCl₄ > NH₃

5. CCl₄ > CH₃CH₂F > NH₃ > CH₃OH

Explanation:

“Like dissolves like.” Heptane is hydrocarbon, and thus completely non-polar. Carbon tetrachloride is most soluble since even though the C–Cl bond is polar, there is no net dipole in the molecule, followed by fluoroethane, which is polar. Methanol is small and very polar (exhibiting hydrogen bonding), and ammonia is the most polar of the liquids, and thus least soluble.

017 4.0 points

Assume the molar solubility of silver chromate (Ag₂CrO₄) is represented as x . Which of the following expressions correctly expresses the relationship between the molar solubility of silver chromate and the solubility product constant (K_{sp}) for this compound?

1. $K_{\text{sp}} = x^2$

2. $K_{\text{sp}} = 2x^3$

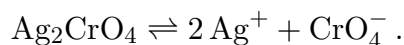
3. $K_{\text{sp}} = 4x^3$ **correct**

4. $K_{\text{sp}} = 2x^2$

5. $K_{\text{sp}} = 4x^2$

Explanation:

The equation for the dissociation of Ag₂CrO₄ is written as



The expression for $K_{\text{sp}} = [\text{Ag}^+]^2 [\text{CrO}_4^-]$. Since the molar solubility is x , K_{sp} can be

rewritten (in terms of x) as

$$K_{\text{sp}} = [2x]^2 [x] = 4x^3.$$

$[\text{Ag}^+] = 2x$ because for every salt molecule that dissociates, 2 Ag^+ ions are produced.

018 4.0 points

Which of the following would raise the vapor pressure of a sample of mercaptane in a closed container?

- I) increasing the temperature of the sample
- II) decreasing the size of the container
- III) adding a non-volatile solute to the liquid

1. I and III
2. I only **correct**
3. II and III
4. III only
5. I, II and III
6. II only
7. I and II

Explanation:

Because evaporation is always an endothermic process, a substance's vapor pressure is always directly proportional to its temperature. Adding a non-volatile solute to any substance will decrease its vapor pressure. Factors such as sample size and container size do not influence the vapor pressure.

019 4.0 points

The solubility product constant of Ag_2CrO_4 is 9.0×10^{-12} . What is the molar solubility of Ag_2CrO_4 in a solution in which the silver ion concentration is maintained at 2.0×10^{-3} M by addition of AgNO_3 ?

1. 4.5×10^{-9}
2. 4.0×10^{-3}
3. 1.3×10^{-4}

4. 5.6×10^{-7}

5. 2.3×10^{-6} **correct**

Explanation:

020 4.0 points

Which of the following highly soluble salts would be the most useful for lowering the freezing point of a solution?

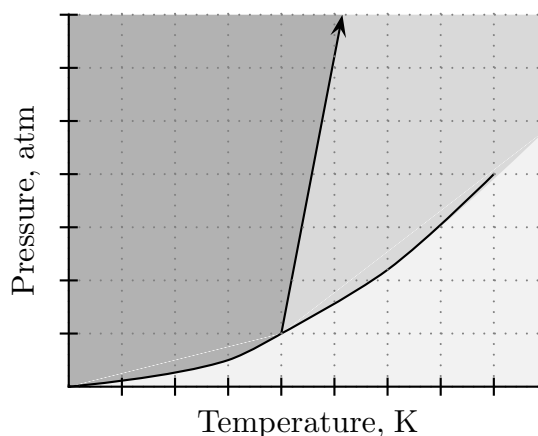
1. $(\text{NH}_4)_3\text{PO}_4$
2. KBr
3. $\text{Ce}_2(\text{SeO}_4)_3$ **correct**
4. Cs_2SO_4
5. $\text{Cs}_2\text{Cr}_2\text{O}_7$

Explanation:

Cerium Selenate, $\text{Ce}_2(\text{SeO}_4)_3$, has the largest van't Hoff factor ($i = 5$), and would require the smallest molar quantity to lower a solution's freezing point by a given amount.

021 4.0 points

The phase diagram for a pure compound is given below.



All of the following could have a similar phase diagram except

1. benzene.
2. water. **correct**

3. methanol.

2. < 0 ; > 0

4. carbon dioxide.

3. > 0 ; > 0

5. carbon tetrachloride.

4. < 0 ; $= 0$

Explanation:

5. > 0 ; $= 0$ correct

022 4.0 points

Theoretically, it would be harder to dissolve ($\text{NaCl}/\text{Al}_2\text{S}_3$) in water because the (higher/lower) the charge density, the lower the solubility.

1. Al_2S_3 , higher **correct**

2. NaCl , higher

3. NaCl , lower

4. Al_2S_3 , lower

Explanation:

Al_2S_3 has a higher charge density (Al^{3+} , S^{2-}) than NaCl (Na^+ , Cl^-). High charge density corresponds to high lattice energy and thus much more endothermic (i.e. less spontaneous) dissolution.

023 4.0 points

What is the molar solubility of Ag_2S ? The K_{sp} is 6.3×10^{-51} .

1. 6.37×10^{-15}

2. 1.16×10^{-17} **correct**

3. 7.94×10^{-26}

4. 2.82×10^{-13}

5. 5.8×10^{-18}

Explanation:

024 4.0 points

$\Delta G_{\text{vap}}^\circ$ for $\text{H}_2\text{O}(\ell)$ at 85°C is (< 0 , $= 0$, > 0) and at 100°C is (< 0 , $= 0$, > 0).

1. < 0 ; < 0

Explanation:

025 4.0 points

K_{sp} for CaF_2 is 3.9×10^{-11} . Would a precipitate of CaF_2 form if $\text{Ca}(\text{NO}_3)_2$ and NaF solutions were mixed such that $[\text{Ca}^{2+}] = 2.0 \times 10^{-4} \text{ M}$, and $[\text{F}^-] = 3.0 \times 10^{-4} \text{ M}$?

1. no **correct**

2. yes, because Q is larger than K_{sp}

3. yes, because Q is smaller than K_{sp}

Explanation: