version: master [redacted]

This MC portion of the exam should have 19 questions. The point values are given with each question. Bubble in your answer choices on the bubblehseet provided. Your score is based on what you bubble on the bubblesheet and not what is circled on the exam. Below are some constants you might want to use.

Water Data

$T_{fp} = 0°C$ $\quad \Delta H_{vap} = 2260\ J{\cdot}g^{-1}$

$T_{bp} = 100°C$ $\quad \Delta H_{fus} = 334\ J{\cdot}g^{-1}$

$C_{ice} = 2.09\ J{\cdot}g^{-1}{\cdot}K^{-1}$ $\quad K_b = 0.512°C/m$

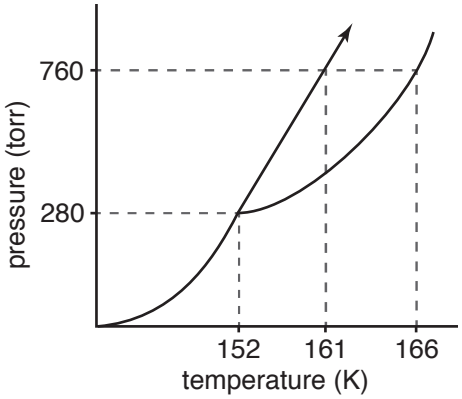
$C_{water} = 4.184\ J{\cdot}g^{-1}{\cdot}K^{-1}$ $\quad K_f = 1.86°C/m$

$C_{steam} = 2.03\ J{\cdot}g^{-1}{\cdot}K^{-1}$

$R = 8.314$ J/mol K

$R = 0.08206$ L atm/mol K

Figure 1



Phase Diagram for Xenon

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1 What are the signs for the change in enthalpy and change in entropy when a system undergoes the phase transition of freezing? (4 pts)

- A. $\Delta H < 0$, $\Delta S < 0$
- B. $\Delta H < 0$, $\Delta S > 0$
- C. $\Delta H > 0$, $\Delta S < 0$
- D. $\Delta H > 0$, $\Delta S > 0$

Explanation: Freezing is a transition from a liquid to a solid. This is both exothermic (solids are lower in enthalpy than liquids) and it lowers the entropy (solids are lower in entropy than liquids).

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2 In which solvent do you expect hexane (C_6H_{14}) to be miscible? (4 pts)

- A. C_5H_{12}
- B. CH_3OH
- C. H_2O
- D. CH_3CN
- E. CH_3COOH

Explanation: miscible liquids should have similar intermolecular forces (like dissolves like). Hexane is non-polar and only has dispersion interactions. The same is true for pentane C_5H_{12}.

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3 Calculate the number of grams of nitrogen gas that will dissolve in 125 L of water if the partial pressure of the nitrogen gas is 0.79 atm. Henry's law constant for nitrogen gas is 0.00060 M/atm. (4 pts)

- A. 1.7 g
- B. 0.83 g
- C. 0.059 g
- D. 0.00047 g

Explanation: Henry's law constant times the partial pressure of the gas above the solution is equal to the concentration of the dissolved gas in the solution:

$$C_{\text{gas}} = k_{\text{H}} \cdot P_{\text{gas}}$$

$$C_{\text{gas}} = 0.0006(0.79) = 0.000474M$$

You then convert concentration to moles by multiplying by volume: $(0.000474)(125) = 0.05925$ moles. Mass is obtained by multiplying the moles of nitrogen by its molar mass: (0.05925 mol)(28 g/mol) = 1.7 g.

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4 What mass of potassium can be produced by the reaction of 175.0 g of Na with 175.0 g of KCl? $\text{Na} + \text{KCl} \rightarrow \text{NaCl} + \text{K}$ (4 pts)

- A. 91.78 g
- B. 296.7 g
- C. 183.5 g
- D. 148.4 g

Explanation: This is a limiting reagent question. To decide the amount of K formed, you must first decide which is the limiting reactant. The Na to KCl molar ratio is one to one. So whichever reactant has the fewer number of moles at the start is the limiting reactant. Since the mass of each is the same and KCl has a greater molar mass than Na, the KCl will be the limiting reactant. To determine the amount of grams K produced start with what is given and convert to grams K.

$$\left(\frac{175.0 \text{ g KCl}}{1}\right)\left(\frac{1 \text{ mol KCl}}{74.55 \text{ g KCl}}\right)\left(\frac{1 \text{ mol K}}{1 \text{ mol KCl}}\right)\left(\frac{39.1 \text{ g K}}{1 \text{ mol K}}\right) = 91.78 \text{ g K}$$

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5 You have a sample containing 15 grams of solid ethanol together with 15 g of liquid ethanol. The sample is at the freezing temperature of ethanol, -114°C. What happens when you initially place this mixture in a deep freezer which is held at -180°C and energy flows out of the sample in the form of heat? (4 pts)

- A. The temperature of the sample increases while the liquid ethanol freezes.
- B. The temperature of the sample decreases while the liquid ethanol freezes.
- C. The temperature of the sample remains constant while the liquid ethanol freezes.
- D. The temperature of the sample remains constant while the solid ethanol melts.
- E. The temperature of the sample remains constant and the relative amount of liquid and solid ethanol remains constant.

Explanation: none

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6 You have a sample of Xe at 164 K and 760 torr. You reduce the pressure to 250 torr. According to figure 1, what happens? (4 pts)

- A. Nothing. No phase change occurs.
- B. It vaporizes.
- C. It solidifies.
- D. It melts.
- E. It condenses.

Explanation: The substance is a liquid at the given starting temperature and pressure. As we reduce the pressure to the new 250 torr value, we cross the vapor pressure line into the gas region.

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7 You have a 100 g sample of water at standard pressure and 70°C. How much energy is required to heat this sample to steam at 120°C? (4 pts)

- A. 243 kJ
- B. 21 kJ
- C. 239 kJ
- D. 247 kJ
- E. 185 kJ
- F. 17 kJ

Explanation: You have three steps: The heat required to heat the water to the boiling point, the heat required to boil the water, and the heat required to heat the steam to 120°C.

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8 Which aqueous solution would you expect to have the highest boiling point? (4 pts)

- A. 0.2 M sugar
- B. 0.2 M KCl
- C. 0.2 M Na_2SO_4
- D. All of these solutions would have the same boiling point.

Explanation: The sodium sulfate will have the highest effective molality: the highest concentration of solute particles in solution, since each sodium sulfate will ionize into two sodium ions and one sulfate ion.

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9 According to figure 1, what is the normal boiling point of Xe? (4 pts)

- A. 166 K
- B. 152 K
- C. 161 K
- D. $<$ 152 K
- E. $>$ 166 K

Explanation: Then normal boiling point is the temperature at which the vapor pressure equals 760 torr.

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10 An aqueous solution at 25°C contains 35 grams of a non-ionizing solute with MW = 83.1 g/mol. The total mass of the solution is 215 grams. The vapor pressure of pure water at 25°C is 23.76 torr. What is the vapor pressure of the solution? (4 pts)

- A. 22.8 torr
- B. 23.76 torr
- C. 0.96 torr
- D. 2.96 torr
- E. 23.36 torr

Explanation: none

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11 What is the boiling point of an aqueous solution of 1.2 m $CaCl_2$? (4 pts)

- A. 101.8 °C
- B. 100.6 °C
- C. 101.2 °C
- D. 100.4 °C
- E. 103.6 °C

Explanation: The solution has three ions, so the net concentration is 3.6 m. The change in boiling point is (3.6 m)(0.512°C m^{-1}) = 1.8°C. So the new boiling point is 100 + 1.8 = 101.8 °C.

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12 You have a solution that contains 25 g of an unknown non-ionizing polymer in a 250 mL solution of chloroform ($CHCl_3$). The osmotic pressure of this solution at 25°C is found to be 0.056 atm. What is the molecular weight of the unknown solid? (4 pts)

- A. 43,500 g mol^{-1}
- B. 3,650 g mol^{-1}
- C. 10,870 g mol^{-1}
- D. 41,000 g mol^{-1}
- E. 1,740 g mol^{-1}

Explanation: The osmotic pressure is given by $\Pi = MRT$. Using R = 0.08206 L-atm K^{-1} mol^{-1} and T = 298.15 K the concentration of the solution is

$M = \frac{(0.056 \text{ atm})}{(0.08206 \text{ L}-\text{atm K}^{-1} \text{ mol}^{-1})(298.15\text{K})} = 2.3 \times 10^{-3}$

Since volume of the solution is 250 mL, this means you have a total of 5.75×10^{-4} moles of solute. Given the mass of 25g this gives a molecular weight of $MW = \frac{25 \text{ g}}{5.75 \times 10^{-4} \text{ moles}} = 43,500$ g/mol

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13 The solubility of $PbBr_2$ is 8.44 g/L at 20°C. What is K_{sp} for this compound? (4 pts)

- A. 4.9×10^{-5}
- B. 1.0×10^{-3}
- C. 1.2×10^{-5}
- D. 1.1×10^{-6}
- E. 5.3×10^{-4}

Explanation: (8.44g/L / 367g/mol) = .023 M. $[Pb^{2+}]$ = 0.023 M, $[Br^-]$ = 0.046 M. $K_{sp} = [Pb^{2+}][Br^-]^2 = (0.023)(0.046)^2 = 4.9 \times 10^{-5}$

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14 Which of the following compounds has the lowest solubility in water? (4 pts)

- A. $PbBr_2$, $K_{sp} = 6.6 \times 10^{-6}$
- B. AgI, $K_{sp} = 8.5 \times 10^{-17}$
- C. $Sr_3(PO_4)_2$, $K_{sp} = 4 \times 10^{-28}$
- D. $Ag(CH_3COO)$, $K_{sp} = 4.4 \times 10^{-3}$

Explanation: You can approximate the molar solubility as the n^{th} root of the K_{sp}. For AgI this is about 10^{-8} M. That is the smallest value. $Sr_3(PO_4)_2$) has the smallest K_{sp}, but it makes 5 ions. So the solubility is approximately the 5th root of the K_{sp} or 10^{-6}

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15 You have an aqueous solution that contains a wide array of different ions along with a solid chunk of Ag_3PO_4 ($K_{sp} = 9.8 \times 10^{-21}$) in it. The concentration of PO_4^{3-} in the solution is 2.0×10^{-2} M. What is the concentration of the silver ion? (4 pts)

- A. 7.9×10^{-7} M
- B. 2.6×10^{-7} M
- C. 2.3×10^{-6} M
- D. 4.4×10^{-6} M
- E. 9.9×10^{-6} M

Explanation: $K_{sp} = [Ag^+]^3[PO_4^{3-}]$ $9.8 \times 10^{-21} = [Ag^+]^3$ (2.0×10^{-2}). $[Ag^+] = 7.9 \times 10^{-7}$ M

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16 You have two closed containers with ether. Each container has a total volume of 1L. One container is filled with 750 mL of liquid ether. The other container has 500 mL of liquid ether. How does the partial pressure of the ether in the gas phase above the liquid compare in the two containers? (4 pts)

- A. It is the same in both containers.
- B. It is higher in the container with 750 mL.
- C. It is higher in the container with 500 mL.

Explanation: The vapor pressure is independent of the amount of liquid or the volume the gas can occupy.

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17 Which of the following would have the lowest vapor pressure? (4 pts)

A. NH_3
B. CH_3NH_2
C. $C_4H_9NH_2$
• D. $C_8H_{17}NH_2$

Explanation: All will have hydrogen bonding, but $C_8H_{17}NH_2$ will have significantly more dispersion forces. The stronger IMFs will lead to a lower vapor pressure.

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18 The vapor pressure of liquids increases as the temperature increases because (4 pts)

• A. at a higher temperatures the kinetic energy distribution of molecules shifts to higher values.
B. intermolecular forces have a strength that is inversely proportional to temperature.
C. vapor pressure does not increase with temperature, it decreases.
D. as temperature increases the volume increases.
E. the enthalpy decreases with increasing temperature.

Explanation: As the temperature increases the kinetic energy of the molecules increase. Therefore compared to the intermolecular forces holding them in the liquid state, more of them have a sufficient energy to enter the gas phase.

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19 $K_{sp} = 4.64 \times 10^{-3}$ for $Ba(NO_3)_2$. What is the concentration of the nitrate ion in a saturated $Ba(NO_3)_2$ solution? (4 pts)

• A. 0.210 M
B. 0.105 M
C. 0.167 M
D. 0.333 M
E. 0.068 M
F. 0.136 M

Explanation: $K_{sp} = [Ba^{2+}][NO_3^-]^2$. $[Ba^{2+}] = x$. $[NO_3^-] = 2x$. Therefore $K_{sp} = 4x^3 = 4.64 \times 10^{-3}$. $x = 0.105$ M. $[NO_3^-] = 2x = 0.210$ M.

- Make sure you complete the front and back of the free response portion.
- Remember to bubble in ALL your answers BEFORE time is called.
- Sign your exam, bubblesheet, AND free response page.
- Turn in ALL parts: exam copy, bubblesheet, and free response.