

CH 302 Spring 2008 Worksheet 4 Answer Key Practice Exam 1

1. Predict the signs of ΔH and ΔS for the sublimation of CO_2 .
- $\Delta H > 0, \Delta S > 0$
 - $\Delta H > 0, \Delta S < 0$
 - $\Delta H < 0, \Delta S > 0$
 - $\Delta H < 0, \Delta S < 0$

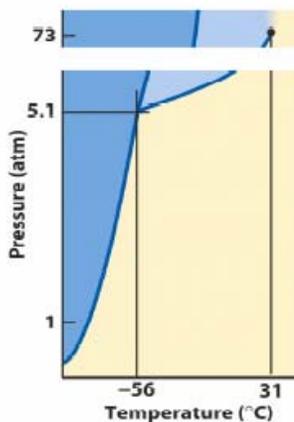
Answer: This reaction happens only at higher temperatures, which means $\Delta H > 0$ and $\Delta S > 0$.

2. Vapor pressure increases _____ with temperature.
- Linearly
 - Exponentially
 - Logarithmically
 - Quadratically

Answer: Recall the Clausius-Clapeyron equation. Pressure is related exponentially to temperature.

3. Which of the following salts will dissolve most easily in water?
- LiF
 - MgO
 - BN
 - KBr

Answer: The salt with the lowest charge density will dissolve the easiest. BN and MgO both have multiple charges, so they have high charge density. Li^+ and F^- are smaller than K^+ and Br^- , so LiF has a higher charge density than KBr .



4. For this question, refer to the phase diagram shown above. What is the phase of this substance at -56°C and 5.1 atm ?
- Solid
 - Liquid
 - Gas
 - Mixture of solid and gas
 - Mixture of solid, liquid, and gas
 - Supercritical fluid

Answer: This is the triple point, which is the point at which solid, liquid, and gas are all at equilibrium with each other.

5. For this question, refer to the phase diagram shown above question 4. The substance is originally held in a container at -60°C and 20 atm . It is then heated to room temperature, and next allowed to expand to atmospheric pressure. What happens to the substance?
- The liquid in the container boils.
 - The liquid in the container becomes a supercritical fluid.
 - The gas in the container becomes a supercritical fluid.
 - The solid in the container sublimates.
 - The solid in the container melts, then the resulting liquid boils.
 - The solid in the container sublimates, and then the resulting gas condenses.

Answer: Just trace the two steps on the phase diagram.

6. 1 kg of water starts at 200°C and is allowed to cool to room temperature. For water, the specific heats are $c_{\text{ice}} = 2.093\text{ J/g}^{\circ}\text{C}$, $c_{\text{water}} = 4.186\text{ J/g}^{\circ}\text{C}$, and $c_{\text{steam}} = 2.009\text{ J/g}^{\circ}\text{C}$. The enthalpy changes are $\Delta H_{\text{fusion}} = -335.5\text{ J/g}$ and $\Delta H_{\text{vaporization}} = 2.26\text{ kJ/g}$. What is ΔH_{sys} for this process?
- -2775 J
 - -2775 kJ
 - $+2775\text{ kJ}$
 - -1745 kJ
 - $+1745\text{ kJ}$

Answer: Divide the process into three stages.

Cool steam $200^{\circ}\text{C} \rightarrow 100^{\circ}\text{C}$:

$$\Delta H = mc_{\text{steam}}\Delta T = (1000\text{g})(2.009\text{ J/g}^{\circ}\text{C})(-100^{\circ}\text{C}) = -201\text{ kJ}$$

Condense steam:

$$\Delta H = m\Delta H_{\text{melting}} = -m\Delta H_{\text{vaporization}} = (1000\text{ g})(2.26\text{ kJ/g}) = -2260\text{ kJ}$$

Cool water $100^{\circ}\text{C} \rightarrow 25^{\circ}\text{C}$:

$$\Delta H = mc_{\text{water}}\Delta T = (1000\text{g})(4.186\text{ J/g}^{\circ}\text{C})(-75^{\circ}\text{C}) = -314\text{ kJ}$$

$$\Delta H_{\text{tot}} = -201\text{ kJ} + -2260\text{ kJ} + -314\text{ kJ} = -2775\text{ kJ}$$

7. Which of the following gases will be most soluble in water?
- CH₄
 - O₂
 - CCl₄
 - He
 - Cl₂

Answer: Since all of these are nonpolar, solubility in water can be ranked based on size. Smaller molecules can more easily fit between water molecules.

8. Rank the following in terms of increasing miscibility with water: CH₃OH, CH₄, CH₃CH₂OH, CH₃CH₂CH₂OH.
- CH₃CH₂CH₂OH < CH₃CH₂OH < CH₃OH < CH₄
 - CH₄ < CH₃OH < CH₃CH₂OH < CH₃CH₂CH₂OH
 - CH₄ < CH₃CH₂CH₂OH < CH₃CH₂OH < CH₃OH
 - CH₃OH < CH₃CH₂OH < CH₃CH₂CH₂OH < CH₄

Answer: CH₄ is nonpolar, so it is not soluble in water. All of the alcohol (molecules with –OH) groups are polar, but the shorter the carbon backbone attached to the –OH, the soluble the molecule is in water.

9. 25 g of acetic acid (CH₃COOH) and 75 g of ethanol (CH₃CH₂OH) are mixed together. At 25°C, the vapor pressures of these compounds are 16 and 59 torr, respectively. What is the vapor pressure of the mixture?
- 37.50 torr
 - 48.25 torr
 - 26.75 torr
 - 50.25 torr
 - 24.75 torr

Answer: $n_{\text{acetic}} = 25\text{g} / (60\text{ g/mol}) = 0.417\text{ mol}$
 $n_{\text{ethanol}} = 75\text{ g} / (46\text{ g/mol}) = 1.63\text{ mol}$
 $P_{\text{acetic}} = X_{\text{acetic}} P^{\circ}_{\text{acetic}}$
 $= (0.417\text{ mol}) / (0.417\text{ mol} + 1.63\text{ mol}) \times 16\text{ torr} = 3.26\text{ torr}$
 Similarly, $P_{\text{ethanol}} = 46.99\text{ torr}$. So
 $P_{\text{total}} = 3.26\text{ torr} + 46.99\text{ torr} = 50.25\text{ torr}$

10. Butanol boils at 118°C and has a ΔH_{vap} of 50 kJ/mol. What is butanol's vapor pressure at room temperature, 25°C? Recall that 1 atm = 760 torr and R = 8.314 J/mol K.
- 6.28 torr
 - 91965 torr
 - 756.4 torr

d. 763.7 torr

Answer: Remember that the boiling point is the point at which the vapor pressure equals 1 atm.

$$\ln(P_1/P_2) = \Delta H/R (1/T_2 - 1/T_1)$$

$$P_1 = P_2 \exp[\Delta H/R(1/T_2 - 1/T_1)]$$

$$P_1 = (760 \text{ torr}) \exp[(50000 \text{ J/mol})/(8.314 \text{ J/molK})(1/391 \text{ K} - 1/391 \text{ K})]$$

$$P_1 = 6.28 \text{ torr}$$

11. The equilibrium constant K for



is 2.5×10^{-25} at 298 K. Predict its value at 500. K. The heat of vaporization for this reaction is + 198 kJ/mole.

- a. 65.1×10^{-25}
- b. 2.5×10^{-11}
- c. 2.5×10^{-8}
- d. 4×10^{10}

Just stick the numbers in the Van't Hoff equation. Remember to convert the heat of vaporization to Joules.

12. Which of these is **not** an example of using a colligative property to your advantage?

- a. Adding salt to water so that your spaghetti cooks faster.
- b. Mixing ethylene glycol and water in your radiator so that the liquid remains liquid over a wide range of temperatures.
- c. Cooking your spaghetti in a pressure cooker so that it cooks faster.
- d. Salting the roads after it snows.

Answer: Colligative properties are properties of solutions, where the solute affects a property of the solvent. A pressure cooker raises the boiling point, but is not a solution property.

13. 20 g of BaCl_2 is added to 1 L of water ($d_{\text{water}} = 1 \text{ g/mL}$). What is the boiling point of the water, given the boiling point of pure water is 100°C and K_b for water is 0.512°C/m ?

- a. 99.852°C
- b. 100.148°C
- c. 99.951°C
- d. 100.0492°C
- e. 89.760°C
- f. 110.240°C

Answer: $n_{\text{BaCl}_2} = 20 \text{ g} / (208 \text{ mol/g}) = 0.0962 \text{ mol}$
 $m = n_{\text{BaCl}_2} / m_{\text{H}_2\text{O}} = 0.0962 \text{ mol} / (1 \text{ kg}) = 0.0962 \text{ m}$
 $\Delta T_b = i m K_b = 3(0.0962 \text{ m})(0.512^\circ\text{C/m}) = 0.148^\circ\text{C}$
 $T_b = T_b^\circ + \Delta T_b = 100.148^\circ\text{C}$
 Don't forget the van't Hoff factor with $I = 3$

14. Which is the correct expression of K given the reaction
 $\text{NaCl (aq)} + \text{AgNO}_3 \text{ (aq)} \rightarrow \text{NaNO}_3 \text{ (aq)} + \text{AgCl (s)}$

a. $K = \frac{[\text{NaNO}_3][\text{AgCl}]}{[\text{NaCl}][\text{AgNO}_3]}$

b. $K = \frac{[\text{NaCl}][\text{AgNO}_3]}{[\text{NaNO}_3][\text{AgCl}]}$

c. $K = \frac{[\text{NaNO}_3]}{[\text{NaCl}][\text{AgNO}_3]}$

Answer: Remember that you don't consider solids when constructing an expression for K .

15. Nothing happens. Which of the following values for K best reflects this statement?

a. 1×10^{-4}

b. 1

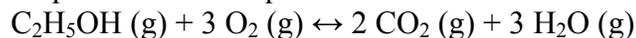
c. 1×10^4

d. 1×10^{-14}

e. 1×10^{62}

When you initiate a reaction and nothing happens, this means that the concentration of the reactants remains effectively unchanged and the ratio of products to reactants is negligible. The best answer is the smallest numerical value.

16. For some temperature, assume that K_p for the combustion reaction below is 10^5 . You mix 1 atm each of $\text{C}_2\text{H}_5\text{OH}$, O_2 , H_2O , and CO_2 . Which of the following is a possible set of equilibrium concentrations?



a. $P_{\text{C}_2\text{H}_5\text{OH}} = 1.31 \text{ atm}$, $P_{\text{O}_2} = 1.92 \text{ atm}$, $P_{\text{CO}_2} = 0.390 \text{ atm}$, $P_{\text{H}_2\text{O}} = 0.0845 \text{ atm}$

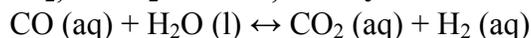
b. $P_{\text{C}_2\text{H}_5\text{OH}} = 0.0652 \text{ atm}$, $P_{\text{O}_2} = 0.691 \text{ atm}$, $P_{\text{CO}_2} = 1.94 \text{ atm}$, $P_{\text{H}_2\text{O}} = 1.62 \text{ atm}$

c. $P_{\text{C}_2\text{H}_5\text{OH}} = 0.691 \text{ atm}$, $P_{\text{O}_2} = 0.0652 \text{ atm}$, $P_{\text{CO}_2} = 1.62 \text{ atm}$, $P_{\text{H}_2\text{O}} = 1.94 \text{ atm}$

d. $P_{\text{C}_2\text{H}_5\text{OH}} = 1.92 \text{ atm}$, $P_{\text{O}_2} = 1.31 \text{ atm}$, $P_{\text{CO}_2} = 0.0845 \text{ atm}$, $P_{\text{H}_2\text{O}} = 0.390 \text{ atm}$

Answer: Plug in and check. $(1.62)^2(1.94)^3 / (0.691)(0.0652)^3 = 100,049 = \sim 10^5$

17. Calculate the equilibrium concentration of CO_2 , given that you start with 1 M each of CO , CO_2 , and H_2 in water, and $K_c = 223$.



- a. 1.98 M
- b. 0.126 M
- c. 0.00893 M
- d. 1.87 M

Answer:

CO (aq)	H ₂ O (l)	CO ₂ (aq)	H ₂ (aq)
1	XXXXX	1	1
-x	XXXXX	+x	+x
1-x	XXXXX	1+x	1+x

$$K = 223 = (1+x)^2/(1-x)$$

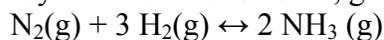
$$x^2 + 2x + 1 = 223 - 223x$$

$$x^2 + 225x - 222 = 0$$

Solving the quadratic equation gives $x = 0.98$

$$[\text{CO}_2] = 1 + 0.98 = 1.98 \text{ M}$$

18. For the formation of ammonia, imagine you start with 1.5 M N₂, 1 M H₂ and 2.5 M NH₃. Which way will the reaction shift, given $K_c = 3.8$?



- a. To the products.
- b. To the reactants.
- c. It won't.
- d. Up.
- e. Down.

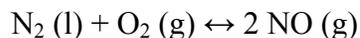
Answer: $Q = (2.5)^2/(1.5)(1)^3 = 4.17 > K$, so the reaction shifts to the left.

19. An exothermic reaction is placed over a flame. What happens to the reaction?

- a. Nothing happens.
- b. The reaction shifts toward the reactants.
- c. The reaction shifts toward the products.

Answer: Heat is added to the reaction, so it shifts to use up heat. It does this by shifting to the left, undergoing an endothermic reaction (since it's the reverse of an exothermic reaction).

20. The pressure on the vessel in which the following reaction is taking place is doubled. What happens to the reaction?



- a. Nothing happens.
- b. The reaction shifts toward the reactants.
- c. The reaction shifts toward the products.

Answer: The reaction shifts to decrease the pressure. Since there are fewer gas molecules on the left, the reaction shifts to the left to decrease the total

amount of gas present. Be careful to always look at the state of the materials in the chemical or physical process.

21. At 298 K, ΔG for a given reaction is -25.7 kJ. What is K for this reaction at 298 K?
- 1.01
 - 0.990
 - 3.20×10^4
 - 3.13×10^{-5}
 - 22.0

Answer: $K = \exp[-\Delta G/RT]$
 $= \exp[-(-25700 \text{ J})/(8.314 \text{ J/molK} \times 298 \text{ K})] = 31986$

22. At some temperature, $K_w = 5 \times 10^{-14}$. What is the pOH of pure water at this temperature?
- 6.00
 - 6.65
 - 7.00
 - 7.35
 - 8.00

Answer: For pure water, $[\text{OH}^-] = [\text{H}^+] = K_w^{1/2} = (5 \times 10^{-14})^{1/2} = 2.24 \times 10^{-7}$
 $\text{pOH} = -\log[\text{OH}^-] = -\log[2.24 \times 10^{-7}] = 6.65$

23. Which of the following is the most likely temperature at which $K_w = 5 \times 10^{-14}$ as above, given $K_w = 1 \times 10^{-14}$ at room temperature?
- 0 °C
 - 12 °C
 - 25 °C
 - 50 °C

Answer: Remember that K_w increases as the temperature increases. Thus, the given K_w must occur at a temperature greater than 25°C.

24. What is the OH^- concentration of a solution that is pH 4.6?
- 9.4
 - 2.5×10^{-5}
 - 4×10^{-10}
 - 1×10^{-10}
 - 7

Remember to use K_w to convert from pH to POH.

25. Which of the following is the strongest base?
- Ammonia, $K_b = 1.8 \times 10^{-5}$
 - Aniline, $K_b = 4.2 \times 10^{-10}$
 - Dimethylamine, $K_b = 5.1 \times 10^{-4}$
 - Pyridine, $K_b = 1.4 \times 10^{-9}$
 - Urea, $K_b = 1.5 \times 10^{-14}$

Answer: Larger K_a/K_b means stronger acid/base.

26. What is the pH of a 0.05 M solution of $\text{Ba}(\text{OH})_2$. Hint, you really don't need a calculator to do this problem?
- 1
 - 13
 - 1.3
 - 12.7

Remember to double the amount of OH^- from the barium hydroxide

27. The $\text{p}K_a$ of hydrofluoric acid (HF) is 3.15. If 132 g of HF is dissolved in 1 L of water, what is the pOH of the resulting solution?
- 13.5
 - 12.83
 - 14.66
 - 1.17
 - 14.82

Answer: $K_a = 10^{-3.15}$

$$C_a = n_{\text{HF}}/V_{\text{soln}} = (132 \text{ g} / 20 \text{ g/mol})/1 \text{ L} = 6.6 \text{ M}$$

$$[\text{H}^+] = (K_a C_a)^{1/2} = (10^{-3.15} \times 6.6)^{1/2} = 0.0684$$

$$\text{pH} = -\log(0.0684) = 1.17$$

$$\text{pOH} = 14 - \text{pH} = 14 - 1.17 = 12.83$$

28. 1 mole of ethylenediamine is dissolved in 1 L water, and the resulting $[\text{OH}^-]$ is 3.16×10^{-11} M. What is K_a for ethylenediamine?
- 10^{-22}
 - 10^{-7}
 - 5×10^{-6}
 - 1.8×10^{-2}

Answer: $[H^+] = 10^{-14}/[OH^-] = 10^{-14}/(3.16 \times 10^{-11}) = 3.16 \times 10^{-4} \text{ M}$
 $[H^+] = (K_a C_a)^{1/2}$
 $K_a = [H^+]^2/C_a = (3.16 \times 10^{-4} \text{ M})^2/1 \text{ M} = 1.00 \times 10^{-7}$

29. Which of the following is **not** a strong acid?
- a. HF
 - b. HCl
 - c. HBr
 - d. HI
 - e. HClO₄
 - f. HClO₃

Answer: Memorize the strong acids and bases—really, it is kind of essential.

30. 100 ml of 0.2 M formic acid and 200 ml of .1 M lithium formate are mixed together, What type of solution is formed and what is the pH? $K_a = 1 \times 10^{-4}$ for formic acid. Hint: You should feel silly if you use a calculator.
- a. Buffer, 4
 - b. Weak acid, 2.3
 - c. Weak base, 10
 - d. Buffer, 2.3
 - e. Weak acid, 4
 - f. Weak base, 11.7

Note that this is a mixture of conjugate acid and base. Also note that the number of moles of each is equal so that without doing any math you have a 1:1 ratio of acid to base and therefore the pH = the pK_a.