EASY PACKET 1 ANSWER KEY

1. Determine the dominant intermolecular force in a pure sample of PH_3.

   Dipole-dipole

2. A gas phase atom with the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$ loses three electrons. What is the electron configuration of the resulting gas phase ion?

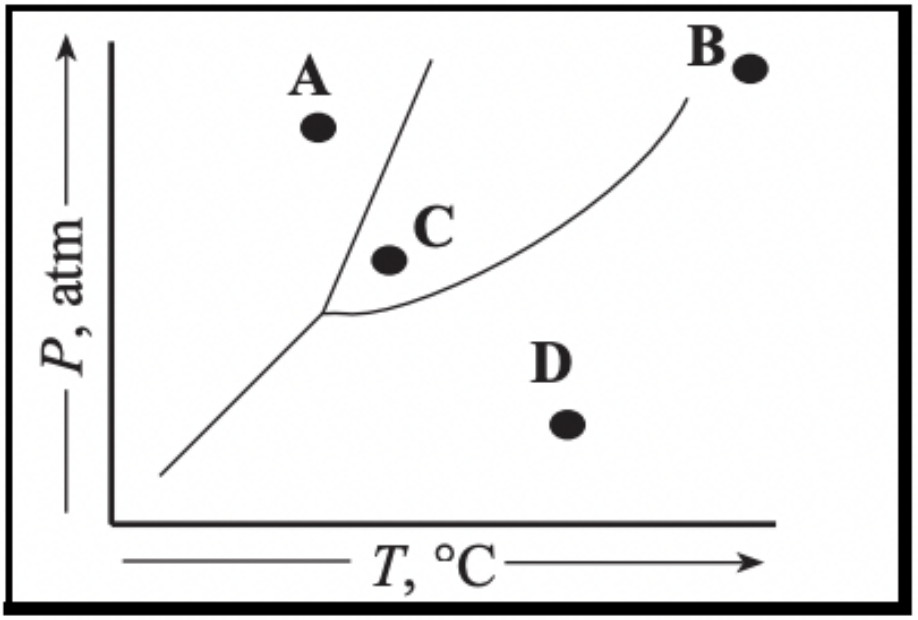
   $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$

3. Which substance is most likely to be soluble in a nonpolar solvent?
   a. Glucose
   b. Sodium Chloride
   c. Lithium fluoride
   d. Sulfur

   d. Sulfur

EASY PACKET 2 ANSWER KEY

1. Which point in the phase diagram best represents supercritical conditions?



B

2. Consider a sample of O_2 gas at 298 K. Calculate the v_{mp}(in $\frac{m}{s}$) for this sample. Given: Ideal gas constant $R = 8.314\ J/mol{\cdot}K$.

$$v_{mp} = \sqrt{\frac{2RT}{M}} = \sqrt{\frac{2\times 8.314\ J/mol{\cdot}K}{32g/mol\times 10^{-3}kg/g}} = 394\ m/s$$

3. Water molecules undergo autoionization: $2H_2O \rightleftharpoons H_3O^+ + OH^-$. Similarly, liquid ammonia autoionizes: $2NH_3 \rightleftharpoons NH_4^+ + NH_2^-$. The natural log of the ion product constant for ammonia (pK_{NH_3}) at $-33^{\circ}C$ is 26.29. What is the concentration of NH_4^+ and NH_2^- in liquid ammonia at 25 degree celsius? (round to 1 decimal place)

Both $7.2*10^{-14}$ M

EASY PACKET 3 ANSWER KEY

1. If at 100 degrees celsius, water has an autoionization constant $K_w = 1.0 \times 10^{-12}$. If an aqueous solution has a pH of 7 at 100 degree celsius, is it acidic, neutral or basic?

    a. Acidic
    b. Neutral
    c. Basic

    c

2. Water molecules undergo autoionization: $2H_2O \rightleftharpoons H_3O^+ + OH^-$. Similarly, liquid ammonia autoionizes: $2NH_3 \rightleftharpoons NH_4^+ + NH_2^-$. Guanidine is a weak base in water: $C(NH_2)_2NH + H_2O \rightleftharpoons C(NH_2)_3^+ + OH^-$. Assume it behaves similarly in liquid ammonia, write an equation for its dissociation in ammonia.

    $C(NH_2)_2NH + NH_3 \rightleftharpoons C(NH_2)_3^+ + NH_2^-$

3. NH_3 is converted to NO_2^- by nitrifying bacteria in natural waters. Is this an oxidation or reduction reaction?
    a. Oxidation
    b. Reduction
    c. Not redox reaction

    a

EASY PACKET 4 ANSWER KEY

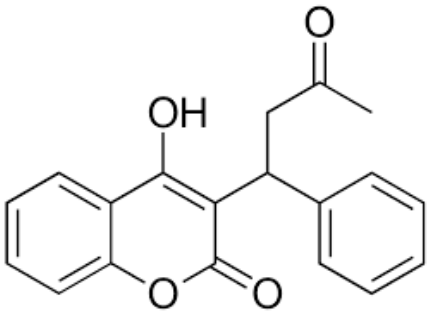
1. Arrange the following substances based on their melting points, from highest to lowest: N_2, CO, NH_3.

   $NH_3 > CO > N_2$

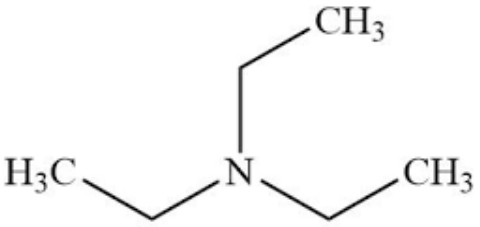
2. Arrange the following covalent compounds based on their melting points, from highest to lowest: SiC, Si_3N_4, SiO_2

   $SiO_2 > Si_3N_4 > SiC$

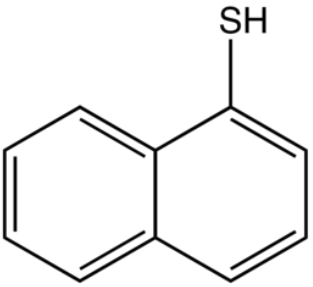
3. Which of the substances below cannot participate in hydrogen bonding?

a. 

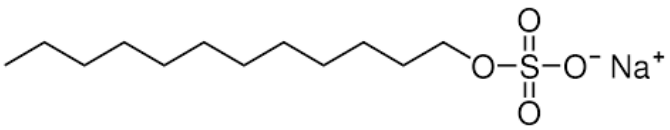
Warfarin

b. 

Triethylamine

c. 

1-naphthalenethiol

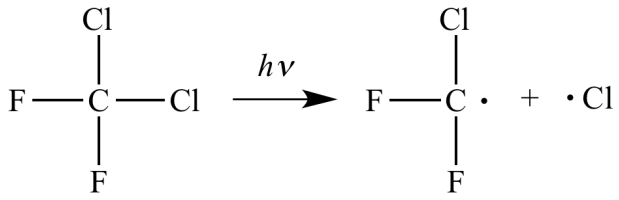
d. 

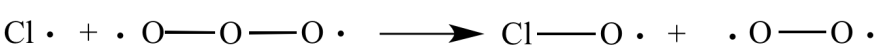
Sodium dodecyl sulfate

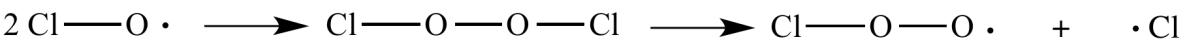
c

EASY PACKET 5 ANSWER KEY

1. Shown below is the mechanism of the destruction of the ozone layer by freon. Which species is most likely acting as a catalyst?







   a. $Cl\bullet$
   b. ClO_2
   c. CCl_2F_2
   d. $ClO\bullet$

a

2. Which of the following groups of species can coexist in an aqueous solution in abundance?
   a. Ca^{2+}, NO_3^-, I^-, H^+
   b. OH^-, Al^{3+}, Mg^{2+}, Cl^-
   c. ClO^-, NH_4^+, Fe^{3+}, SO_4^{2-}
   d. Na^+, Br^-, MnO_4^-, H^+

d

3. For the following reaction, $N_2O_4 \rightleftharpoons 2NO_2$, the K_p at 300 K is 0.140 atm. What is the K_p of $4NO_2 \rightleftharpoons 2N_2O_4$?

K□ $= \frac{1}{(original\ K_p)^2} = \frac{1}{(0.140)^2} = 51.0$

EASY PACKET 6 ANSWER KEY

1. A 2-L container contains 0.400 mol of O_2 gas and 0.200 mol of H_2 gas. At 100℃, what is the total pressure, in atm, of the gasses?

$$P = \frac{nRT}{V}O_2 + \frac{nRT}{V}H_2 = \frac{0.400\ mol\ (0.08206\ L\ atm/mol\ K)(398\ K)}{2\ L} + \frac{0.200\ mol\ (0.08206\ L\ atm/mol\ K)(398\ K)}{2\ L}$$
$$= 9.80\ atm$$

2. For the following reaction, $Zn_{(s)} + 2HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$, assuming it goes to completion, how many moles of H_2 gas would be produced if 3.45 g Zn reacts with 10.0 mL of 6 M HCl?

$$\frac{3.45\ grams}{1} \times \frac{1\ mol\ Zn}{65.38\ grams} \times \frac{1\ mol\ H_2}{1\ mol\ Zn} = 0.0528\ mol\ H_2$$
$$\frac{10.0\ mL}{1} \times \frac{6\ mol\ HCl}{1000\ mL} \times \frac{1\ mol\ H_2}{2\ mol\ HCl} = 0.03\ mol\ H_2$$

Therefore HCl is the limiting reactant, and **0.03 mol** H_2 will be produced.

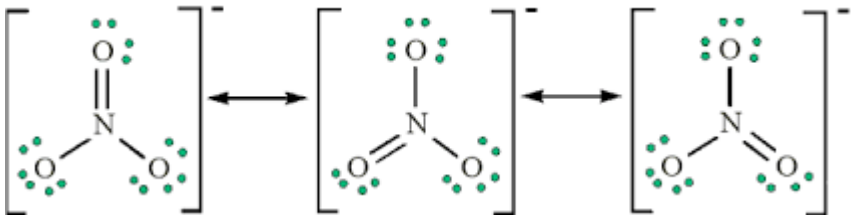
3. Write the equilibrium expression for the following decomposition reaction, $NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$.

$$K = [H_2O][CO_2]$$

EASY PACKET 7 ANSWER KEY

1. What is the molar mass of CH_3COOH?
   60.1 g/mol

2. Draw the preferred Lewis structures for NO_3^-. Indicate any equivalent resonance structures if necessary.
   Answer:



3. What is the formal charge, if any, on the nitrogen atom in NO_2?
   +1

EASY PACKET 8 ANSWER KEY

1. Using your knowledge of intermolecular interactions, predict which molecule would have the highest boiling point: C_4H_8, CH_3CH_2OH, *or* CH_3CH_2COOH?

   CH_3CH_2COOH

2. Which molecule has a trigonal pyramidal molecular geometry: NH_3, NH_4^+, BCl_3?
   NH_3

3. The pK_a of benzene sulfonic acid, $C_6H_5SO_3$ at 25℃ is 0.70. Calculate the K_a of this acid at 25℃.
   $K_a = 10^{-0.70} = 0.200$

EASY PACKET 9 ANSWER KEY

1. What is the conjugate base of H_2SO_4?
   HSO_4^-

2. A solution made up of a strong base and a weak acid is most likely to have a pH:
   a. Greater than 7
   b. Around 7
   c. Less than 7

   a

3. Calculate the molality of a solution made by adding 0.10 g $BaCl_2$ to 25.00 mL of water. Assume the density of water is 1.00 g/mL.

   $$molality = \frac{mol\ solute}{kg\ solvent} = \frac{0.10\ grams\ BaCl_2}{25.00\ mL\ water} \times \frac{1\ mol\ BaCl_2}{208.23\ grams} \times \frac{1\ mL\ water}{1.00\ g\ water} \times \frac{1000\ g}{1\ kg} = 0.0192\ m$$

   0.0192m

EASY PACKET 10 ANSWER KEY

1. A dilution is prepared by adding 1 mL of a 6 M HCl solution to 100 mL of water. What is the HCl concentration of the new solution?

   $m_1v_1 = m_2v_2$

   $(1\ mL)(6\ M) = (101\ mL)(x\ M),\ x = 0.0594\ M$

   0.0594M

2. What is the electron configuration for a +1 arsenic cation? (noble gas configuration is acceptable)

   $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^2$

   (or $[Ar] 4s^2 3d^{10} 4p^2$)

3. True/False: The following set of quantum numbers (given as n, l, m) could describe an electron in the 3d sublevel : (3, 3, -1).

   False

   (- l quantum number is defined by numbers from 0 to n - 1, so 3 is not a possible value given that n = 3.)

EASY PACKET 11 ANSWER KEY

1. How many electrons are found in the 5^{th} energy level?

   $\#\ electrons\ =\ 2(\#\ energy\ level)^2\ =\ 50$

   50

2. How many unbonded electrons are present in formaldehyde, H_2CO, given that C is the central atom?

   4

3. True/False: Methane (CH_4) is able to undergo hydrogen bonding with hydrofluoric acid (HF).

   False

EASY PACKET 12 ANSWER KEY

1. What direction does the dipole moment lie in CH_3Cl?
    a. Towards the the carbon
    b. Towards the hydrogens
    c. Towards the chlorine
    d. There is no dipole moment in the molecule

    c

2. The auto-ionization of water, given by the equation $2H_2O \rightleftharpoons H_3O^+ + OH^-$, is known to be an endothermic process. If the temperature of the reaction was lowered, which way would the reaction proceed?
    a. To the right
    b. To the left
    c. The reaction would not shift as it would still remain in equilibrium

    b

3. The reaction between water and formic acid, HCOOH, has a K_a of 1.77×10^{-4}. When formic acid is titrated with sodium hydroxide, NaOH, which of the following listed indicators would be best used to detect the equivalence point?
    a. Thymol blue: pH range 1.2-2.8
    b. Methyl orange: pH range 3.2-4.4
    c. Bromothymol blue: pH range 6.0-7.6
    d. Phenolphthalein: pH range 8.2-10.0

b: $pKa = -log(1.77 \times 10^{-4}) = 3.80$, choose an indicator with a pH range near the value of the pKa

EASY PACKET 13 ANSWER KEY

1. A 10 g ice cube (specific heat = 2.09$\frac{J}{g \cdot C}$, enthalpy of fusion = 334 J/g) at -15℃ is added to 25 g of water (specific heat = 4.184 $\frac{J}{g \cdot C}$) at 37℃. What is the final temperature of the water?

   Final temperature of the water: 1.48℃
   Heat gained by the ice cube = Heat lost by the water

$$(2.09\frac{J}{g \cdot C})(10\ g)(15°) + (334\ J/g)(10\ g) + (4.184\frac{J}{g \cdot C})(10\ g)(x) = -(4.184\frac{J}{g \cdot C})(25\ g)(x - 37°C)$$

$$313.5 + 3340 + 41.84x = -104.6x + 3870.2$$

$$146.44x = 216.7$$

$$x = 1.48℃$$

2. Estimate the enthalpy of formation of 1 mol of HBr for the following reaction: $H_2 + Br_2 \rightarrow 2HBr$, given the following average bond dissociation energies: H-H = 436 kJ/mol, Br-Br = 193 kJ/mol, and H-Br = 366 kJ/mol.

   Enthalpy of Formation = (energy of reactant bonds) - (energy of product bonds)
   For 1 mol of HBr: $\frac{1}{2}H_2 + \frac{1}{2}Br_2 \rightarrow HBr$

$$(0.5)(436\ kJ/mol) + (0.5)(193\ kJ/mol) - 366\ kJ/mol = -51.5\ kJ/mol$$

   -51.5 kJ/mol

3. Consider the following balanced, heterogeneous chemical reaction:

$$BaO_2(s) + 4HCl\,(g) \rightleftharpoons BaCl_2\,(s) + 2H_2O\,(g) + Cl_2(g)$$

   Using the Law of Mass Action, write the expression for the equilibrium constant, K, for this reaction.

$$K = \frac{P_{Cl2} * P^2_{H2O}}{P^4_{HCL}}$$

EASY PACKET 14 ANSWER KEY

1. Consider the following radial wavefunction for the H atom:

$$Rn,\ell = \frac{1}{2\sqrt{6}}\left[\frac{Z}{a_0}\right]\sigma \ where\ \sigma = \frac{Zr}{a_0}$$

Determine if there are any radial nodes. If there are, please indicate where they are.

There are no radial nodes

nodes are present if $R_{n,\ell} = 0$

$R_{n,\ell} = 0$ when $\sigma = 0$ which happens when $r = 0$.

But there are no nodes since $r = 0$ is a boundary condition.

2. Consider the following radial wavefunction for the H atom:

$$Rn,\ell = \frac{1}{2\sqrt{6}}\left[\frac{Z}{a_0}\right]\sigma \ where\ \sigma = \frac{Zr}{a_0}$$

If the radial wavefunction given describes an electron in a hydrogen atom that has a total energy equal to –3.4 eV, identify the quantum numbers n and ℓ associated with this function. Hint: you can simplify using Bohr's model.

n=2 , $l \in \{0, 1\}$

$E = -3.4eV = -13.6eV\left(\frac{1}{n^2}\right)$

$n = 2$

$l \in \{0, 1\}$

possible sets: $(2,0) \Rightarrow 2s$, $(2,1) \Rightarrow 2p$

3. Write the balanced chemical equation for the combustion of liquid pentane (C_5H_{12}).

EASY PACKET 15 ANSWER KEY

$C_5H_{12\,(l)} + 8\ O_{2\,(g)} \rightarrow 5\ CO_{2\,(g)} + 6\ H_2O_{(g)}$

1. Consider the balanced reaction shown below to answer the following questions.

$$N_2\,(g) + O_2\,(g) \rightleftharpoons 2NO\,(g) \text{ at 245 K, K = 2.25.}$$

Determine if each of the initial conditions below will result in the reaction as written to proceed to the right in order to reach equilibrium.

a. P(N_2) = 1.0 atm; P(O_2) = 1.5 atm; P(NO) = 1.5 atm

Yes, Q = 1.5^2/(1.5*1.0) = 1.5

b. The partial pressure of each gas is 0.45 atm

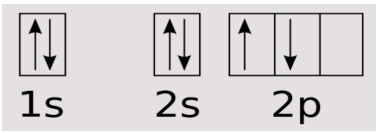
Yes, Q = 0.45^2/(0.45*0.45) = 1

c. P(N_2) = 0.20 atm; P(O_2) = 0.20 atm; P(NO) = 0.50 atm

No, Q = 0.5^2/(0.2*0.2) = 6.25

EASY PACKET 16 ANSWER KEY

1. Which rule does the following configuration (of a ground state atom) violate?



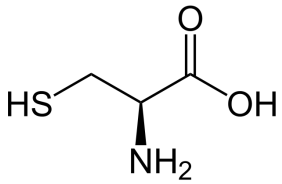
Hund's Rule

2. Balance the reaction below:

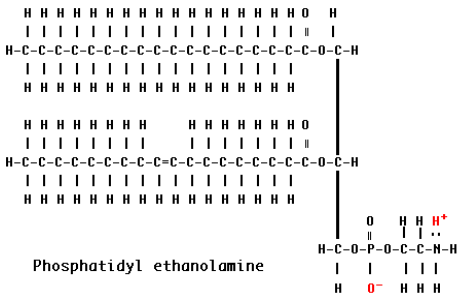
$S + HNO_3 \rightleftharpoons H_2SO_4 + NO_2 + H_2O$

$S + 6HNO_3 \rightleftharpoons H_2SO_4 + 6NO_2 + 2H_2O$

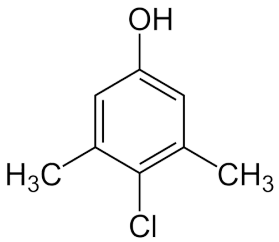
3. Which of the following compounds **cannot** act as a hydrogen bond donor but **can** act as a hydrogen bond acceptor?

a. 

Cysteine

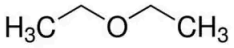
b. 

Phospholipid

c. 

Chloroxylenol

EASY PACKET 17 ANSWER KEY

d.  Diethylether

D

1. Write the net ionic reduction half-reaction for the following redox reaction. Be sure to include phases.

$Fe_2O_{3\,(s)} + 2Al_{(s)} \rightarrow Al_2O_{3\,(s)} + 2Fe_{(l)}$

Reduction: $Fe^{3+}_{(aq)} + 3e^- \rightarrow Fe_{(l)}$

2. Write the net ionic oxidation half-reaction for the following redox reaction. Be sure to include phases.

$Fe_2O_{3\,(s)} + 2Al_{(s)} \rightarrow Al_2O_{3\,(s)} + 2Fe_{(l)}$

Oxidation: $Al_{(s)} \rightarrow Al^{3+}_{(aq)} + 3e^-$

3. For the following situations, determine if the reaction will shift left, shift right, or more information is needed.

$$Zn\,(s) + 2H_3O^+(aq) \rightarrow Zn^{2+}\,(aq) + H_2(g) + H_2O(l)$$

Note: this reaction is exothermic.

a. Increasing the pH
Shift left

b. Increasing the temperature
Shift left

EASY PACKET 18 ANSWER KEY

1. $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$
   You combine 20 g of C_2H_6 and 30 g of O_2. Identify the limiting reagent of this reaction.

   Oxygen

   Convert the mass of each chemical into moles first. For this question, using a rough value for each chemicals' molar mass is alright.
   20/(12*2+6)=2/3
   30/(16*2)=15/16

   Then, divide the number of moles with the stoichiometric coefficient given in the equation.
   C2H6: (⅔)/2=⅓=0.333
   O2: (15/16)/7=0.134
   0.134<0.333

   O2 is the limiting reagent.

2. A sample of 1.23 mol of an ideal gas occupies a container volume of 0.04 m^3. Calculate the pressure in the container.

   Key: Ideal Gas, applying ideal gas law. PV=nRT
   V=0.04 m^3=40 L, n=1.23 mol, T=25 C=25+273.15=298.15 K
   P=nRT/V=1.23 mol*0.0821 (L • atm/ mol • K) *298.15K/40L=**0.7527 atm**

   Note: if T used 298 K instead of 298.15 K and leads to discrepancy to this result, that is acceptable. And the issue of rounding is lenient here, 0.7 atm, 0.75 atm, 0.753 atm are all fine. Other answers with reasonable proximity to this result should be accepted.

3. True or False:
   CO_2 contains bonds that are longer than those in O_3.

CO_2 → double bonds → bond length = 2

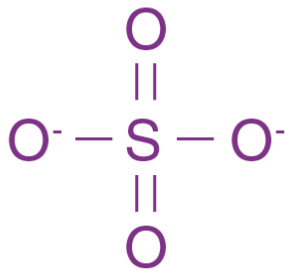
EASY PACKET 19 ANSWER KEY

O_3 → a single bond and a double bond in resonance → bond length = 1.5

CO_2 bonds are shorter

False

1. Draw the Lewis dot diagram for SO_4^{2-}. Write the formal charges on the four oxygen atoms. The order you write them in does not matter



-1, -1, 0, 0

2. Here is a list of elements: lithium, nitrogen, oxygen, fluorine, beryllium
   a. Which one has the highest electronegativity?
      Fluorine
   b. Which one has the largest second ionization energy?
      Beryllium
   c. In the ground state, which element has only 1 electron in each of the three p orbitals?
      Nitrogen

3. What is the name of the VSEPR geometry of phosphorus pentafluoride?
   Trigonal bipyramidal

EASY PACKET 20 ANSWER KEY

1. In a solution, the $[H^+] = 10^{-3}$. What is the pH, the $[OH^-]$, and the pOH?

   pH = 3
   $[OH^-] = 10^{-11}$
   pOH = 11

2. At pressures above the critical point, what is the expected phase of a substance?
   Supercritical fluid

3. Consider the following reaction: $CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COO^-_{(aq)} + H_3O^+_{(aq)}$.
   Given $\Delta G^o_{rxn} = 27.2\ kJ/mol$, calculate the equilibrium constant (K_a) at 25°C.

   $lnK_a = -\frac{\Delta G^o_{rxn}}{RT} = -10.98$

   $K_a = 1.71 \times 10^{-5}$

EASY PACKET 21 ANSWER KEY

1. Consider the following reaction: $CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COO^-_{(aq)} + H_3O^+_{(aq)}$. Given $\Delta H^o_{rxn} = -0.3\ kJ/mol$ for the reaction shown above, calculate the equilibrium constant (K_a) at 90°C. You may assume that ΔH^o_{rxn} and ΔS^o_{rxn} are temperature independent over this temperature range.

$$ln\frac{K_2}{K_1} = -\frac{\Delta H^o_{rxn}}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$ln\frac{K_2}{1.71\times10^{-5}} = -\frac{-0.3\ kJ/mol}{8.314\times10^{-3}\ kJ/mol}\left(\frac{1}{363K} - \frac{1}{298K}\right)$$

$$K_2 = 1.7 \times 10^{-5}$$

2. What is the name of the process in which solid is converted directly into gas?
Sublimation

3. The pH of pure water at 50°C is 6.85. What is the value of K_w at 50°C? Report your answer to the nearest 3 significant figures.

$$10^{-6.85} = 1.41 \times 10^{-7}$$

$$K_w = (1.41 \times 10^{-7})^2 = 2.00 \times 10^{-14}$$