HARD PACKET 1   ANSWER KEY

1. A 18.1 L closed vessel contains 2.53 g H_2O, 5.34 g CO_2, and 3.60 g SO_3. At 50°C, what is the pressure in the vessel (in atm)? Assume these gasses behave ideally.

$2.53g\ H_2O \times \dfrac{1mol}{18.02g\ H_2O} = 0.140\ mol\ H_2O$

$5.34g\ CO_2 \times \dfrac{1mol}{44.01g\ CO_2} = 0.121\ mol\ CO_2$

$3.60\ g\ SO_3 \times \dfrac{1mol}{80.06\ g\ SO_3} = 0.045\ mol\ SO_3$

Total mol of gas = $0.307\ mol$

$PV = nRT$

$P\,(18.1L) = (0.307\ mol)\left(0.08206\dfrac{atm\,L}{mol\,K}\right)(323.15\,K)$

$P = \boxed{0.45\ atm}$

2. At 500 K, the equilibrium constant is defined as $K_p = 2.9 \times 10^3$ for the reaction

$SbCl_{3\,(g)} + Cl_{2\,(g)} \rightleftharpoons SbCl_{5\,(g)}$. A container holds 0.08 atm $SbCl_3$, 1.0×10^{-5} atm Cl_2, and 0.09 atm $SbCl_5$. Calculate the partial pressures (in atm) of the gasses at equilibrium.

Calculate Q_P:

$$Q_P = \frac{P_{SbCl_5}}{(P_{SbCl_3})(P_{Cl_2})} = \frac{0.09}{(0.08)(1.0\times10^{-5})} = 1.1 \times 10^5$$

$Q_P > K_P$, so reactants are formed

Set up equilibrium table:

	$SbCl_3$ +	$Cl_2 \rightleftharpoons$	$SbCl_5$
Initial	0.08	$1.0x10^{-5}$	0.09
Change	+x	+x	-x
Equilibrium	0.08+x	$1.0x10^{-5}$+x	0.09-x

Solve for x using quadratic formula

$$\frac{0.09-x}{(0.08+x)(1.0\times10^{-5}+x)} = 2.9 \times 10^3$$

x = 3.75 x 10^{-4}

P_{SbCl3} = 0.0804 atm
P_{Cl2} = 3.85 x 10^{-4} atm
P_{SbCl5} = 0.0896 atm

3. At 450°C, $K_P = 6.5 \times 10^{-6}$ for the thermal decomposition of NO_2. Here is the corresponding reaction: $2NO_{2\,(g)} \rightleftharpoons 2NO_{(g)} + O_{2\,(g)}$.

If a reaction vessel at this temperature initially contains only 0.500 atm NO_2, what will be the partial pressures of NO_2, NO, and O_2 in the vessel when equilibrium has been attained?

	P_{NO2}	P_{NO}	P_{O2}
Initial	0.500 atm	0	0
Change	-2x	+2x	+2x
Equilibrium	0.5-2x	2x	2x

Since the equilibrium constant is small, this reaction does not proceed very far to the right, and we may be able to make a simplifying assumption. After placing these values into the equilibrium constant expression, we can solve for x:

$6.5 \times 10^{-6} = \dfrac{2x^3}{(0.5-2x)^2}$

x=7.26x10⁻³ (method of successive approximations)

P_{NO2} = 0.485 atm
P_{NO} = 0.0145 atm
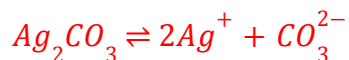P_{O2} = 0.00726 atm

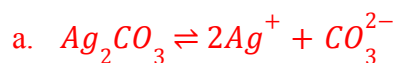# HARD PACKET 2 ANSWER KEY

1. The solubility of silver carbonate in water at 27°C is 1.3×10^{-4} M. What is the solubility of Ag_2CO_3 at 27°C in (a) 0.10 M $AgNO_3$ and (b) 0.10 M Na_2CO_3? (Please ignore the reactions between H_2O and CO_3^{2-}, and between Ag^+ and OH^-.)

Use solubility to find K_{sp}

$Ag_2CO_3 \rightleftharpoons 2Ag^+ + CO_3^{2-}$

$K_{sp} = [Ag^+]^2 [CO_3^{2-}] = (2s)^2 s = 4s^3 = 4(1.3 \times 10^{-4})^3 = 8.8 \times 10^{-12}$

a. $Ag_2CO_3 \rightleftharpoons 2Ag^+ + CO_3^{2-}$
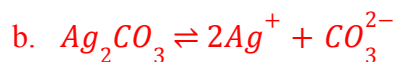
I	0.10	0
C	+2s	+s
E	0.10+2s	s

$8.8 \times 10^{-12} = (0.10 + 2s)^2(s)$

Assume s is small, s<<0.10

$8.8 \times 10^{-12} = (0.10)^2(s)$

$s = 8.8 \times 10^{-10}$ mol/L

b. $Ag_2CO_3 \rightleftharpoons 2Ag^+ + CO_3^{2-}$

I	0	0.10
C	+2s	+s
E	2s	0.10+s

$8.8 \times 10^{-12} = (2s)^2(0.10 + s)$

Assume s is small, s<<0.10

$8.8 \times 10^{-12} = (2s)^2(0.10)$

$s = 4.7 \times 10^{-6}$ mol/L
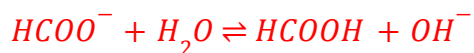
HARD PACKET 2 ANSWER KEY

2. A 25 mL of 0.25 M aqueous solution of $HCOOH$ is titrated with 0.1 M aqueous solution of $NaOH$ at 25°C. What is the pH of the solution at the equivalence point at 25°C? Given: For $HCOOH$, $K_a = 1.7 \times 10^4$ at 25°C.

At the equivalence point, all the initial $HCOOH$ molecules are converted to $HCOO^-$.

$n(HCOO^-) = n(HCOOH) = (0.25\,M)(0.025\,L) = 0.00625\,mol$

$[HCOO^-] = n(HCOO^-)/V(total) = 0.00625\,mol/0.0875\,L = 0.0714M$

$HCOO^- + H_2O \rightleftharpoons HCOOH + OH^-$

I 0.0714 M	0	0
C -x	+x	+x
E 0.0714 M - x	x	x

$K_b = \dfrac{K_w}{K_a} = 5.88 \times 10^{-11} = \dfrac{x^2}{0.714-x}$

Using method of successive approximations

$x = 2.05 \times 10^{-6}M$

$pOH = -\log(2.05 \times 10^{-6}) = 5.69$

$pH = 14 - 5.69$

$pH = 8.31$

3. An electron is confined to a 3-D cubic box with $L_x = L_y = L_z = 8.0$ Å. Calculate the velocity (speed), in m/s, of the electron when it occupies the fourth excited energy level.

Ground level: 1, 1, 1

First excited state: (1, 2, 1), (1, 1, 2), (2, 1, 1)

Second ES = (2, 1, 2), (2, 2, 1), (1, 2, 2)

Third. ES: (3, 1, 1), (1, 1, 3), (1, 3, 1).

fourth ES: (2, 2, 2)

$$KE_{2,2,2} = \frac{h^2}{8ml^2}(n_x^2 + n_y^2 + n_z^2) = \frac{(6.626E-34 \text{ J}\cdot\text{s})^2}{8\cdot(9.11E-31\text{kg})(8E-10\text{m})^2}(2^2+2^2+2^2)$$

$$= 1.1295E-18 \text{ J}$$

$$KE = \frac{1}{2}mv^2 = 1.1295E-18 \text{ J}$$

$$v = \sqrt{\frac{1.1295E-18 \text{ J} \cdot 2}{9.11E-31\text{kg}}} = \boxed{1.57E6 \text{ m/s}}$$

$1.57 \times 10^6 \, m/s$

1. Salinity (S) is defined as the weight percentage of total dissolved substances in seawater. It has units of ppt (parts per thousand, ‰). 1 ppt = 1 g/kg. The specific gravity (sg) of seawater is the ratio of its density to pure water at the same temperature. Assume pure water has a density of 1.00 g/mL. Calculate the weight (in g) of NaCl needed to convert 1.00 L, 34 ppt seawater to 35 ppt at room temperature.

Table 2. Specific gravity and refractive index as a function of seawater's salinity of seawater. The bold rows (34-36 ppt) represent the range usually encountered in the open ocean.		
Salinity (ppt)	**Specific Gravity at 25° C**	**Refractive Index (20° C)**
0	1.0000	1.33300
30	1.0226	1.33851
31	1.0233	1.33869
32	1.0241	1.33886
33	1.0249	1.33904
34	**1.0256**	**1.33922**
35	**1.0264**	**1.33940**
36	**1.0271**	**1.33958**
37	1.0279	1.33976
38	1.0286	1.33994
39	1.0294	1.34012

(Long question!)

Initial properties: with subscript 1; final properties: with subscript 2.

$m_{solution,1} = sg_1 V_1$
$m_{salt,1} = sg_1 V_1 S_1$

Let the weight of added NaCl be X g.
$m_{solution,2} = m_{solution,1} + X = sg_1 V_1 + X$
$m_{salt,2} = m_{salt,1} + X = sg_1 V_1 S_1 + X$

$m_{salt,2} = m_{solution,2} * S_2$
$\rightarrow sg_1 V_1 S_1 + X = S_2(sg_1 V_1 + X)$
$\rightarrow X = sg_1 V_1 * (S_2 - S_1)/(1-S_2) = 1.063 * 10^{-3}$ g = <mark>1.063 g (1.05 - 1.07 should be acceptable)</mark>


2. A two bulbed flask contains 7 particles. What is the probability of finding 6 particles on one side and 1 particle on another side. (Rounded to 3 decimal places)

Total possible arrangements: $2^7 = 128$

Probability $= \dfrac{7}{128} + \dfrac{7}{128} = \dfrac{7}{64} \approx \boxed{0.109}$

3. Initially, 1 mol of ideal gas A is in a container in which the following reaction is happening at 298 K, and the pressure inside of the container is 1.0 atm.

$$A(g) \rightleftharpoons B\,(g) \text{ (B is also an ideal gas)}$$
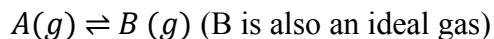
Given that $G_A^{\circ} = 10\ kJ/mol$, $G_B^{\circ} = 5\ kJ/mol$, when $n_A = 0.7\ mol$, calculate the total G in the system (round to 3 decimal places):

$$G_{total} = n_A \times G_A + n_B \times G_B$$

$$G_{total} = n_A \times (G_A^{\circ} + RT ln(p_A)) \quad + n_B \times (G_B^{\circ} + RT ln(p_B))$$

$$G_{total} = 0.7\ mol \times (10\ kJ/mol + 8.31451\ J\ mol^{-1}K^{-1} \times 298K \times ln(0.7))$$

$$+ \ 0.3\ mol \times (5\ kJ/mol + 8.31451\ J\ mol^{-1}K^{-1} \times 298K \times ln(0.3))$$

$$= 6.381380557kJ + 0.605066313kJ \approx \boxed{6.986\ kJ}$$

1. Consider a liquid mixture containing 2 mol of liquid A and 3 mol of liquid B at 25℃. Determine the total equilibrium vapor pressure exerted by two ideal gases A and B (Round to 3 decimal places) $(\Delta G_{vap, A}^{\circ}(25\ °C) = 2.0\ kJ/mol,$

$\Delta G_{vap, B}^{\circ}(25\ °C) = 2.4\ kJ/mol).$

$$\Delta G_{vap, A}^{\circ} = -RT\ln P_A^{\bullet} \Rightarrow P_A^{\bullet} = e^{\frac{-\Delta G_{vap,A}^{\circ}}{RT}} = e^{\frac{-2.0\ kJ/mol}{8.31451\ J\ mol^{-1}K^{-1}\times 298.15K}} = 0.44629\ atm$$

$$\Delta G_{vap, B}^{\circ} = -RT\ln P_B^{\bullet} \Rightarrow P_B^{\bullet} = e^{\frac{-\Delta G_{vap,B}^{\circ}}{RT}} = e^{\frac{-2.4\ kJ/mol}{8.31451\ J\ mol^{-1}K^{-1}\times 298.15K}} = 0.379787431\ atm$$

$$P_{tot, vap} = \chi_A^{liq} \times P_A^{\bullet} + \chi_B^{liq} \times P_B^{\bullet} = 0.4 \times 0.44629\ atm + 0.6 \times 0.379787431\ atm$$

$$P_{tot, vap} \approx 0.406\ atm$$
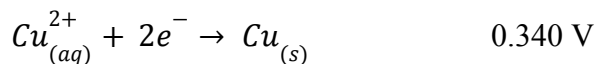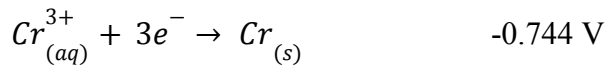
2. An electrochemical cell is constructed with a piece of copper wire in a 1.00 M solution of $Cu(NO_3)_2$ and a piece of chromium wire in a 1.00 M solution of $Cr(NO_3)_3$.

The standard reduction potentials for $Cr^{3+}_{(aq)}$ and $Cu^{2+}_{(aq)}$ are:

$Cr^{3+}_{(aq)} + 3e^- \rightarrow Cr_{(s)}$ -0.744 V

$Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$ 0.340 V

The cell is allowed to operate until the $[Cu^{2+}] = 0.10$ M. Calculate the cell potential at this concentration.

$E^\circ = E_{ox} + E_{red} = 0.744 + 0.340 = 1.084$ V

$[Cu^{2+}]$ goes from 1.0 M to 0.10 M, so $\Delta[Cu^{2+}]$ is -0.90

$\Delta[Cr^{3+}] = 0.90 \times 2/3 = 0.60$ so, $[Cr^{3+}] = 1.60$

Plug these values into the equation,

$E = E^o - \frac{RT}{nF}\left(\frac{[Cr^{3+}]^2}{[Cu^{2+}]^3}\right) = 1.084 - \frac{0.0257}{6}\left(\frac{1.60^2}{0.10^3}\right) = 1.05\ V$

HARD PACKET 4 ANSWER KEY

3. Calculate the work done by 10 g of O_2 expanding isothermally at 20°C from 1 to 0.3 atmospheres of pressure, assuming O_2 behaves as an ideal gas.

$$n = 10g \times \frac{1 \text{ mol } O_2}{31.998g} = 0.313 \text{ mol}$$

$$P_i = 1 atm, \quad P_f = 0.3 \text{ atm}$$

$$T_i = T_f = 293.15 \text{ K}$$

$$V = \frac{nRT}{P}$$

$$V_i = \frac{nRT}{1atm}, \quad V_f = \frac{nRT}{0.3atm}$$

$$w = nRT \ln\left(\frac{V_i}{V_f}\right) = 0.313 \text{ mol} (8.314 \text{ J/mol K})(293.15K) \ln\left(\frac{0.3 \text{ atm}}{1 \text{ atm}}\right) = \boxed{-917.05 \text{ J}}$$

-917.05J

1. If given an initial C_5H_6 concentration of 0.0400 M, a final concentration of 0.0230 M, and a half-life of 12 minutes, what is the second-order rate constant, k, in s^{-1}?

$1/[A] = 2kt + 1/[A]_0$
12 minutes (60 s / 1 min) = 720 seconds
$1/(0.0230\ M) = (2k(720\ s)) / (0.0400\ M)$
$k = (1/(0.0230) - 1/(0.0400))*(1/(2*720\ s))$
$k = 18.5\ s^{-1}$

2. Given a particle in the quantum ground state, find (symbolically) the probability density $P(x) = |\Psi_n(x)|^2$ of this quantum particle as a function of its position in the box?

$$\Psi_n(x) = \sqrt{\frac{2}{L}} \sin(\frac{n\pi x}{L})$$

$$P(x) = \sqrt{\frac{2}{L}} \sin(\frac{\pi x}{L}) * \sqrt{\frac{2}{L}} \sin(\frac{\pi x}{L}) = \frac{2}{L} \sin^2(\frac{\pi x}{L})$$

3. For a given reaction, its equilibrium constant at 25°C is 5.4×10^5. At 540°C, its equilibrium constant has decreased by 98%. Find the standard change in enthalpy of the reaction in kJ/mol.

$$ln(\frac{K_2}{K_1}) = -\frac{\Delta H^\circ}{R}(\frac{1}{T_2} - \frac{1}{T_1})$$

$$K_1 = 5.4 \times 10^5$$

$$K_2 = 1.08 \times 10^4$$

$$T_1 = 298.15\ K$$
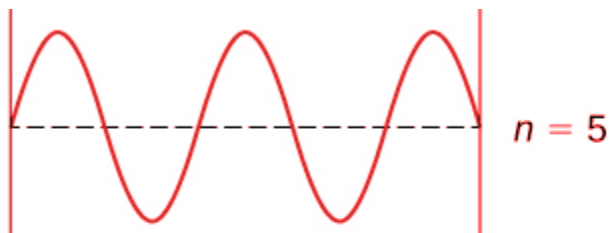
$$T_2 = 813.15\ K$$

$$R = 8.314\ \frac{J}{mol \cdot K}$$

$$ln(\frac{1.08 \times 10^4}{5.4 \times 10^5}) = -\frac{\Delta H^\circ}{8.314\ \frac{J}{mol \cdot K}}(\frac{1}{813.15\ K} - \frac{1}{298.15\ K})$$

$$\Delta H^\circ = -15311.26\ \frac{J}{mol} = -15.31\ \frac{kJ}{mol}$$

1. List the locations that a particle in its fourth excited state in a 1-dimensional box is mostly likely to be found in terms of L, the length of the box.

$n = 5$

$n = 5 \rightarrow \# \ of \ nodes = 4$

Locations of nodes: $\frac{L}{5}, \frac{2L}{5}, \frac{3L}{5}, \frac{4L}{5}$

Locations of most likely to be found = locations with the largest magnitude of amplitude = crests and troughs of each curve $= \frac{L}{10}, \frac{3L}{10}, \frac{L}{2}, \frac{7L}{10}, \frac{9L}{10}$

2. The specific heat capacity for iron is $0.451 \ J/g°C$. For nickel, it takes 273 J of heat to raise the temperature of a 5.04 g block from $25°C$ to $147°C$. Which substance, iron or nickel, would require more heat to raise its temperature by one degree Celsius, assuming both are present in the same amount?

$c_{iron} = 0.451 \ J/g°C$

$q_{nickel} = m_{nickel} c_{nickel} \Delta T$

$273 \ J = (5.04 \ g) \ c_{nickel} (147°C - 25°C)$

$c_{nickel} = 0.444 \ J/g°C$

Iron has a larger specific heat capacity than nickel, therefore it requires more heat to be put in to raise 1 gram of it by 1 degree Calsius.

Final Answer: Iron

3. You measure the root-mean-square speed of 5 mol of ideal gas molecules to be 301.25 m/s. The pressure inside your 4.5 L container is 27.8 atm. What is the identity of this gas?

$PV \; = \; nRT$

$(27.8 \; atm)\,(4.5 \; L) \; = \; (5 \; mol)\,(0.08206 \; \frac{L \; atm}{mol \; K})\,T$

$T \; = \; 304.89 \; K$

$v_{rms} \; = \; \sqrt{\dfrac{3RT}{M}}$

$301.25 \; m/s \; = \; \sqrt{\dfrac{3\,(8.314 \; J/mol \; K)(304.89 \; K)}{M}}$

$M \; = \; 0.083798 \; kg/mol \; = \; 83.798 \; g/mol$

Krypton Gas

1. Given the following information:
   $2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$, ΔH = -2599 kJ/mol
   Heat of Formation of H_2O = -286 kJ/mol
   Heat of Formation of CO₂ = -393.5 kJ/mol
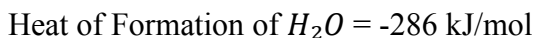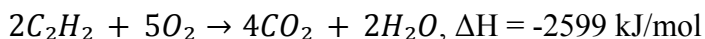
   Calculate the enthalpy of the following reaction:
   $\frac{2}{5}C + \frac{1}{5}H_2 \rightarrow \frac{1}{5}C_2H_2$

   Heat of Formation Reaction of H₂O: $H_2 + \frac{1}{2}O_2 \rightarrow H_2O$

   Heat of Formation Reaction of CO₂: $C + O_2 \rightarrow CO_2$

   Flip the 1st Reaction: $4CO_2 + 2H_2O \rightarrow 2C_2H_2 + 5O_2$

   Multiply the formation reaction of H₂O by 2: $2H_2 + O_2 \rightarrow 2H_2O$

   Multiply the formation reaction of CO₂ by 4: $4C + 4O_2 \rightarrow 4CO_2$

   Add all the reactions: $4C + 2H_2 \rightarrow 2C_2H_2$
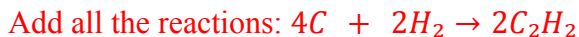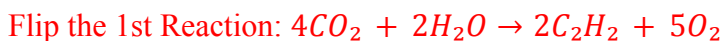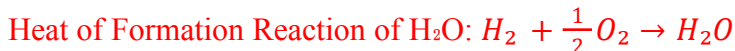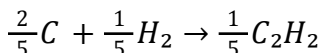
   The sum of enthalpies is therefore: 2599 + -572 + -1574 = 453 kJ/mol

   Divide the Reaction by 10: $\frac{2}{5}C + \frac{1}{5}H_2 \rightarrow \frac{1}{5}C_2H_2$
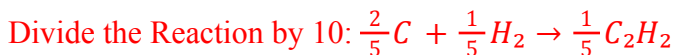
   The enthalpy of formation is therefore: 453/10 = 45.3 kJ/mol

2. You start with an unknown concentration of an aqueous H_2CO_3 solution. When you perform a titration, the acid-base indicator changes color after adding 40 mL of the H_2CO_3 solution to 50 mL of a 0.1 M KOH solution.

    a. What is the concentration of the H_2CO_3 solution?

$$\frac{0.1 \; mol \; KOH}{1 \; L \; KOH} * 0.050 \; L = 0.005 \; mol \; KOH = 0.005 \; mol \; H_2CO_3$$

$$\frac{0.005 \; mol \; H_2CO_3}{0.040 \; L} = 0.125 \; M$$

0.125 M

    b. If bromophenol blue ($pK_a = 4.1$) is used as the indicator, how many milligrams of $Al(OH)_3$ could theoretically be produced if Al^{3+} ion was added at the moment the indicator changes color? Assume that Al^{3+} only interacts with the hydroxide ion.

At the equivalence point, pH of the solution should $= pK_a$ of the indicator (4.1)

Henderson-Hasselbach equation:

$$pH = pK_a - log\left(\frac{[HA]_0}{[A^-]_0}\right) = 4.1 - log\left(\frac{0.005/0.090}{0.005/0.090}\right) = 4.1 - log(1) = 4.1$$

$$pH + pOH = 14$$
$$pOH = 14 - 4.1 = 9.9$$
$$pOH = - log[OH^-]$$
$$[OH^-] = 10^{-pOH} = 10^{(-9.9)} = 1.2589254 * 10^{-10}$$

$$\frac{1.2589254 * 10^{-10} \; mol \; OH^-}{1 \; L \; soln} * 0.090 \; L \; soln = 1.1330329 * 10^{-11} \; mol \; OH^- * \frac{1 \; mol \; Al(OH)_3}{3 \; mol \; OH^-}$$

$$* \frac{78.0027 \; g \; Al(OH)_3}{1 \; mol \; Al(OH)_3} * \frac{1000 \; mg}{1 \; g} = 2.94598751 * 10^{-7} \; mg$$

$$MW \; of \; Al(OH)_3 = 26.982 + (3 * 15.999) + (3 * 1.0079) = 78.0027 \; g/mol$$

2.95 x 10⁻⁷ mg

    c. In the titration curve for this titration, how many points on the plot have a slope that cannot be calculated?

2 equivalence points → 2 non-differentiable points

2

3. An ideal gas consisting of atoms of an unknown element exhibits specific properties under controlled conditions. The gas's root-mean-square velocity is 432.79 m/s. When one mole of this gas is contained in a 24.94-L container, it exerts a pressure of one bar.
   a. Determine the unknown element.

$PV = nRT$

$$(1 \text{ bar})\left(\frac{1\text{atm}}{1.01325 \text{ bar}}\right)(24.94 \text{ L}) = (1 \text{ mol})\left(0.08206 \frac{\text{atm L}}{\text{mol K}}\right)(T)$$

$T = 299.95 \text{ K}$

$$V_{rms} = 432.79 \frac{m}{s}$$

$$\sqrt{\frac{3k_BT}{m}} = 432.79 \frac{m}{s} \qquad\qquad M = \frac{m}{n} = \frac{mN_A}{N} \qquad\qquad m = \frac{NM}{N_A}$$

$$\sqrt{\frac{3(1.381 \times 10^{-23} \frac{J}{K})(299.95 K)}{m}} = 432.79 \frac{m}{s}$$

$$m = 6.635 \times 10^{-26} \text{ kg} = 6.635 \times 10^{-23} \text{ g}$$

$$M = 6.635 \times 10^{-23} \text{ g} \times \frac{6.023 \times 10^{23} \text{ particles}}{1 \text{ mol}} = \boxed{39.94 \text{ g/mol}} \rightarrow \text{Argon}$$

Argon gas

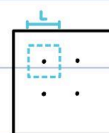   b. Estimate the average distance between atoms in the gas in Angstroms (Å). Use the volume of a cube in your solving process.

$$\bar{V} = \frac{V}{n} = 24.94 \text{ L/mol}$$

$$24.94 \frac{L}{\text{mol}} \times \frac{1 \text{ mol}}{6.023 \times 10^{23} \text{ particles}} \times \frac{10^{-3} \text{ m}^3}{1 L} = 4.14 \times 10^{-26} \text{ m}^3/\text{particle}$$

$$4.14 \times 10^{-23} \text{ L/particle} = d^3$$

$$d = 3.46 \times 10^{-9} \text{ m} = \boxed{34.6 \text{ Å}}$$

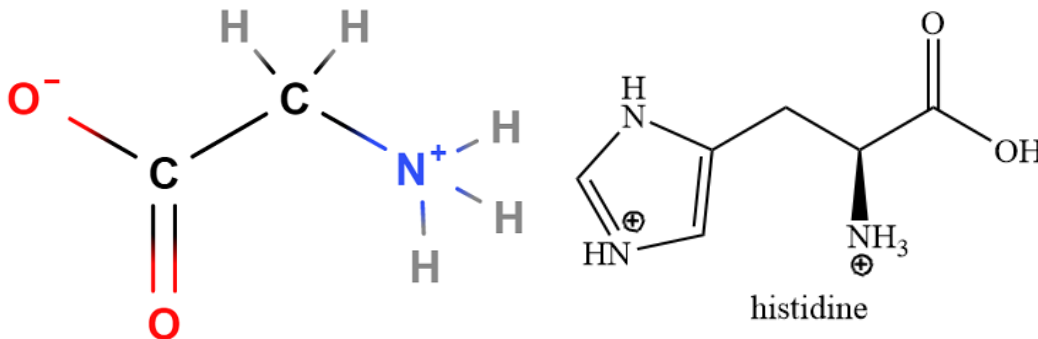34.6 Å

HARD PACKET 8 ANSWER KEY

1. The isoelectric point of a zwitterion is the pH at which the molecule is overall neutral. For example, glycine has an isoelectric point of pH 6. Which of the following is likely to be the isoelectric point of histidine? The two molecules are shown below. Given:

$$pK_a(-COOH) = 1.82, pK_a(-NH_3^+) = 9.17, pK_a(imidazole) = 6.00.$$

Glycine (left)

histidine

    a. 1.82
    b. 3.92
    c. 6.00
    d. 7.59
    e. 9.17

D

2. Compound A is composed entirely of carbons and hydrogens. The combustion of 1 mol of compound A consumes 7.5 mol O_2 to form 5 mol CO_2 and 5 mol H_2O. Give the molecular formula of A.
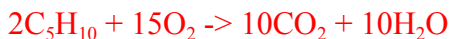
Define the molar coefficient of A to be 1.
A + 7.5O_2 -> 5CO_2 + 5H_2O
multiply both sides by 2 to get integral coefficients
2A + 15O_2 -> 10CO_2 + 10H_2O
The fact that there are 10 CO_2's means that there are 5 carbons in A. The fact that there are 10 H_2O's means that there are 10 hydrogens in A.
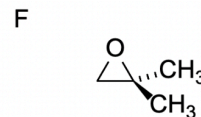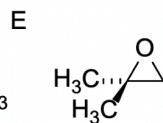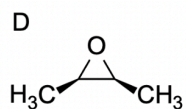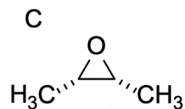2C_5H_{10} + 15O_2 -> 10CO_2 + 10H_2O
A must have the formula C_5H_{10}

3. For the following pairs of compounds indicate whether they are: **structural** isomers, **diastereomers**, **enantiomers**, or **identical**.

A   B   C   D   E   F
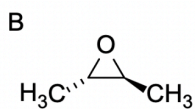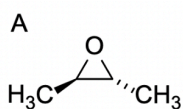
A & B: _____   B & C: _____

C & D: _____   D & E: _____
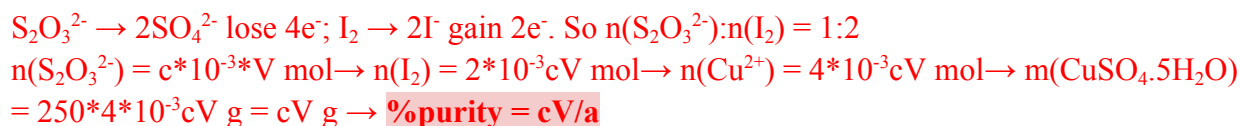
E & F: _____

A & B: enantiomers   B & C: diastereomers   C & D: identical   D & E: structural isomers
E & F: identical

1. The purity of copper sulfate can be determined by iodometry. A sample of $CuSO_4 \cdot 5H_2O$ weighing w grams is dissolved in enough H_2O. Enough KI solution is then added, and the reaction $2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$ occurs. Using starch as an indicator, the solution is then titrated with a c mol/L sodium thiosulfate $(Na_2S_2O_3)$ standard solution, which reduces I_2 to I^-. V mL titrant is added before the solution turns from blue to milky white. What is the % purity of the sample? Express in terms of w, c and V.

$S_2O_3^{2-} \rightarrow 2SO_4^{2-}$ lose 4e⁻; $I_2 \rightarrow 2I^-$ gain 2e⁻. So $n(S_2O_3^{2-})$:$n(I_2)$ = 1:2
$n(S_2O_3^{2-}) = c*10^{-3}*V$ mol→ $n(I_2) = 2*10^{-3}cV$ mol→ $n(Cu^{2+}) = 4*10^{-3}cV$ mol→ $m(CuSO_4.5H_2O)$ = $250*4*10^{-3}cV$ g = cV g → **%purity = cV/a**

2. In the last question, KSCN is added at around the titration endpoint to convert CuI to $Cu(SCN)_2$. This is because CuI absorbs I_2 in the solution. What would happen if KSCN is not added?
    a. The result would be higher than the true purity.
    b. The result would be lower than the true purity.
    c. The result would still be accurate.
    d. Cannot be determined.

B

3. A gas expands by an isothermal, reversible process. The volume of the gas changed from 40 L to 50 L. Calculate the heat transferred to the gas system.

Key: $\Delta U=3/2(nR*\Delta T)$, since $\Delta T=0$ (isothermal), the change in internal energy is 0.
Given that the case, and $\Delta U=Q+W$, where Q stands for heat and W stands for work done on the system. $\Delta U=0$ means Q=W.
Since the volume of the system is changing at miniscule portion during the expansion, so as the pressure piles up, using integration will be the best way to solve this problem.

$W=\int P\, dV$

Since we could substitute P using the ideal gas law, $P=nRT/V$

We have:

$W=\int \frac{nRT}{V}\, dV = nRT\int \frac{1}{V}\, dV = nRT\, ln(V)$

The upper bound of this integration is 50L, and the lower bound is 40L.
So plugging these two figures in:

$W = nRT\, ln(50L) - nRT\, ln(40L) = nRTln(\frac{50L}{40L}) = 1.23\, mole * 8.314\, J/mol\, K * 298.15K * l$

$W = 680.3529\, J$

Therefore,

Q=**680.3529 J**, because all the heat transferred into the system got converted to work done.

Note: R should use the 8.314 one with J in the unit.
Rounding issues are not going to affect the validity of an answer as long as the answer shows reasonable proximity to the correct one.
Usage of 298 K as room temperature, as well as the discrepancies brought by this approximation are acceptable.