

## Recitation Worksheet Two

Name:

MyID:

### Textbook:

Chemistry & Chemical Reactivity

by John C. Kotz, Paul M. Treichel, John R. Townsend, David Treichel

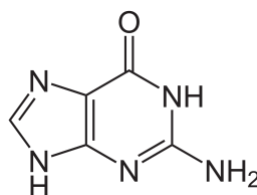
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### Instructions:

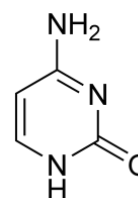
- This recitation worksheet covers Ch. 5.3, 11.1, 11.3-11.6, and 12.6
- Please enter your first and last name as it appears on the eLC roster (do not use a nickname that is not reflected in eLC).
- Your UGA myID is a combination of letters and numbers (example: Dr. Abdelrahman's MyID is ema88805@uga.edu). **Do not use your 81x number.**
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  - You may use an app to annotate the worksheet by placing your answers in the answer boxes and showing your work when appropriate. Afterward, submit the worksheet to Gradescope. You will not need to upload anything to eLC.
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  - If you do not have access to a printer, you may type your answers directly into the worksheet PDF and then submit it to Gradescope. Write your work on separate sheets of paper, convert them to a PDF, and upload to the appropriate dropbox on eLC.
  - There is a Gradescope app available for both iOS and Android devices that allows you to scan and submit your printed work, or you can submit your fillable PDF directly.
- The following criteria **must** be met to be eligible for full credit:
  - You must make sure the pages are in the correct order and have the same layout as the original worksheet when submitting to Gradescope regardless of your submission type.
  - Answers must be written in the corresponding answer boxes.
  - You must show your work when appropriate.
- This worksheet is due no later than **12:00 PM (noon) on the Saturday, August 31<sup>st</sup>.**
- A periodic table and formula sheet are attached to the end of this worksheet. Please keep these attached to your worksheet in the correct order when submitting to Gradescope.

1. Double-stranded DNA consists of nucleobases that tie the DNA strands together. Nucleobases form specific pairs via intermolecular forces, example guanine pairs with cytosine. What is the **major** intermolecular force that exists between guanine and cytosine?

- A. London dispersion forces
- B. Dipole-dipole forces
- C. Hydrogen bonding
- D. Ion-dipole forces



Guanine



Cytosine

2. If water is placed in a plastic graduated cylinder, an inverted "U-shaped" meniscus is observed. The reason behind the inverted "U-shaped" meniscus is

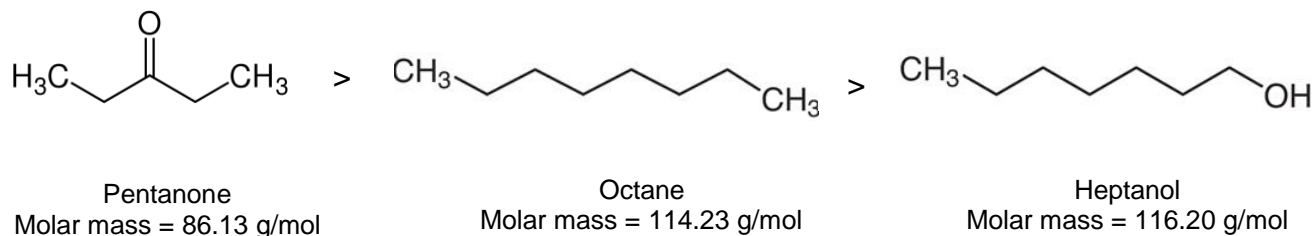
- A. The cohesive forces between the water molecules are stronger than the adhesive forces between the water molecules and the walls of the container
- B. The viscosity of the water is greater than the viscosity of the plastic
- C. Surface tension of the water prevents it from "beading up" inside the container
- D. The molecules of water are forced closer together because of London forces
- E. The cohesive forces between the water molecules are weaker than the adhesive forces between the water molecules and the walls of the container

3. Which of the choices below from A – E represents the correct order of the compounds below in **order of increasing** viscosity?

**CH<sub>3</sub>CHOHCH<sub>2</sub>OH   CH<sub>3</sub>CH<sub>2</sub>OH   CH<sub>3</sub>CH<sub>2</sub>SH   CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>OH**

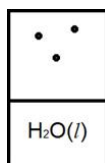
- A. CH<sub>3</sub>CHOHCH<sub>2</sub>OH < CH<sub>3</sub>CH<sub>2</sub>OH < CH<sub>3</sub>CH<sub>2</sub>SH < CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>OH
- B. CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>OH < CH<sub>3</sub>CH<sub>2</sub>SH < CH<sub>3</sub>CH<sub>2</sub>OH < CH<sub>3</sub>CHOHCH<sub>2</sub>OH
- C. CH<sub>3</sub>CHOHCH<sub>2</sub>OH < CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>OH < CH<sub>3</sub>CH<sub>2</sub>OH < CH<sub>3</sub>CH<sub>2</sub>SH
- D. CH<sub>3</sub>CH<sub>2</sub>OH < CH<sub>3</sub>CH<sub>2</sub>SH < CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>OH < CH<sub>3</sub>CHOHCH<sub>2</sub>OH
- E. CH<sub>3</sub>CH<sub>2</sub>SH < CH<sub>3</sub>CH<sub>2</sub>OH < CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>OH < CH<sub>3</sub>CHOHCH<sub>2</sub>OH

4. At room temperature, the vapor pressure pattern is pentanone > octane > heptanol. Which one of the following statements is **FALSE**?



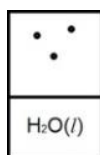

- A. A substance with higher vapor pressure is held together by weaker binding forces
- B. Heptanol has the lowest vapor pressure and strongest intermolecular force due to hydrogen bonding
- C. Octane has lower vapor pressure than pentanone due to London dispersion forces
- D. Heptanol would have a higher boiling point than octane
- E. Pentanone would have a higher boiling point than octane

5. Below is a representation of liquid water in equilibrium with its water vapor in a rigid container at 20.0 °C. The circles represent water vapor. (One dot = 100 mm Hg)

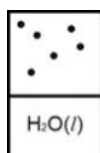


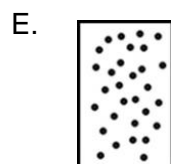
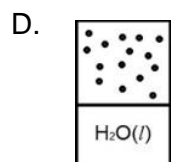
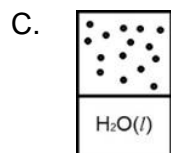
Which diagram below best represents liquid water in equilibrium with its water vapor at 32.7 °C? The heat of vaporization of water is 40.7 kJ/mol.

A.



B.





6. A vapor volume of 1.17 L forms when a sample of liquid acetonitrile,  $\text{CH}_3\text{CN}$  absorbs 1.00 kJ of heat at its normal boiling point ( $81.6^\circ\text{C}$  and 1.00 atm). What is  $\Delta H_{\text{vap}}$  in kJ/mol of  $\text{CH}_3\text{CN}$ ? (**Hint:** you can use the ideal gas law to solve this problem).

kJ/mol

7. For a particular liquid, raising its temperature from 25 °C to 45 °C causes its vapor pressure to double. What is the enthalpy of vaporization of this liquid?

- A. 115 kJ/mol
- B. 288 kJ/mol
- C. 27.3 kJ/mol
- D. 2.53 kJ/mol
- E. 270. kJ/mol

8. What quantity of energy in kJ does it take to convert 0.250 kg of solid methanol ( $\text{CH}_3\text{OH}$ ) at 120 K to gaseous methanol at 400 K? **Do not use scientific notation.**

kJ

Melting point	176 K
Boiling point	338 K
Heat of fusion	2.2 kJ/mol
Heat of vaporization	35.2 kJ/mol
Specific heat (solid)	105 J/mol · K
Specific heat (liquid)	81.3 J/mol · K
Specific heat (gas)	48.0 J/mol · K

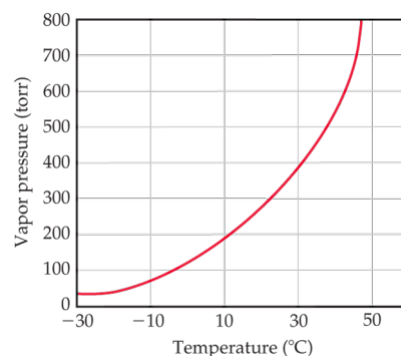
9. If 15.7 g of benzene ( $\text{C}_6\text{H}_6$ ) in the liquid phase at  $50.0\text{ }^\circ\text{C}$  is converted to solid benzene at  $2.0\text{ }^\circ\text{C}$ , calculate  $\Delta H_{\text{sys}}$ . Assume that the pressure is constant during the process.

kJ

Melting point	$5.4\text{ }^\circ\text{C}$
Boiling point	$90.1\text{ }^\circ\text{C}$
Heat of fusion	$9.9\text{ kJ/mol}$
Heat of vaporization	$30.7\text{ kJ/mol}$
Specific heat (solid)	$1.51\text{ J/g}\cdot^\circ\text{C}$
Specific heat (liquid)	$1.80\text{ J/g}\cdot^\circ\text{C}$
Specific heat (gas)	$1.92\text{ J/g}\cdot^\circ\text{C}$

10. The graph shown to the right represents the vapor pressure of CS<sub>2</sub>, a volatile liquid. Which of the following statements regarding CS<sub>2</sub> is true? Select all that apply.

- A. CS<sub>2</sub> has weaker intermolecular forces compared to water
- B. The vapor pressure of CS<sub>2</sub> is greater than the vapor pressure of water
- C. The normal boiling point of CS<sub>2</sub> is approximately 30 °C
- D. The vapor pressure of CS<sub>2</sub> is 200 torr at 10 °C



11. Indicate the **most significant** intermolecular force in each of the compounds or compound pairs below. For each molecule select one of the following choices:

- A. London dispersion forces
- B. Dipole-dipole forces
- C. Hydrogen bond
- D. Ion-dipole forces

For your answer choice insert the letters A – D in the answer box. Example, if the answer is London dispersion forces, then the answer is choice A.

i. LiCl (in water)

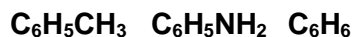
ii. Cl<sub>3</sub>PO

iii. SF<sub>6</sub>

iv.  $\begin{array}{c} \text{CH}_3 \\ | \\ \text{CH}_3 - \text{CH} - \text{CH}_3 \end{array}$

v. H<sub>2</sub>NNH<sub>2</sub>

12. Which of the following choices A – E represents the correct order of the compounds below in order of **decreasing** vapor pressure?



- A.  $\text{C}_6\text{H}_6 > \text{C}_6\text{H}_5\text{NH}_2 > \text{C}_6\text{H}_5\text{CH}_3$
- B.  $\text{C}_6\text{H}_5\text{NH}_2 > \text{C}_6\text{H}_5\text{CH}_3 > \text{C}_6\text{H}_6$
- C.  $\text{C}_6\text{H}_5\text{CH}_3 > \text{C}_6\text{H}_6 > \text{C}_6\text{H}_5\text{NH}_2$
- D.  $\text{C}_6\text{H}_5\text{NH}_2 > \text{C}_6\text{H}_6 > \text{C}_6\text{H}_5\text{CH}_3$
- E.  $\text{C}_6\text{H}_6 > \text{C}_6\text{H}_5\text{CH}_3 > \text{C}_6\text{H}_5\text{NH}_2$
- F.  $\text{C}_6\text{H}_5\text{CH}_3 > \text{C}_6\text{H}_5\text{NH}_2 > \text{C}_6\text{H}_6$

13. Which of the following compound has the **highest** surface tension?

- A.  $\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3$
- B.  $\text{CH}_3\text{CH}_2\text{OCH}_3$
- C.  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$
- D.  $\text{OHCH}_2\text{CH}_2\text{OH}$
- E.  $\text{CH}_2\text{OHCHOHCH}_2\text{OH}$



14. Which statements about vapor pressure below are true? Select all that apply.

☐

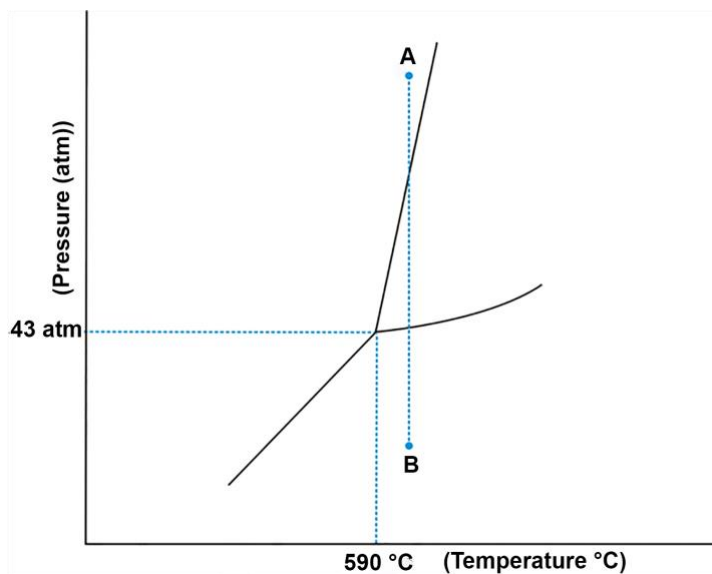
- A. Water in a 150 mL volume container with a diameter of 12 cm has a higher vapor pressure compared to water in a container with a volume of 75 mL and a diameter of 5.5 cm
- B. The stronger the intermolecular forces between the molecules of a liquid the lower the vapor pressure
- C. An increase in temperature of a liquid increases its vapor pressure
- D. Normal melting point is the temperature at which the vapor pressure of a liquid is 760 torr or 1 atm.

15. A liquid has an enthalpy of vaporization of 30.8 kJ/mol. At 273 K it has a vapor pressure of 102 mmHg. What is the normal boiling point of this liquid? (1mm Hg = 1 Torr)

☐

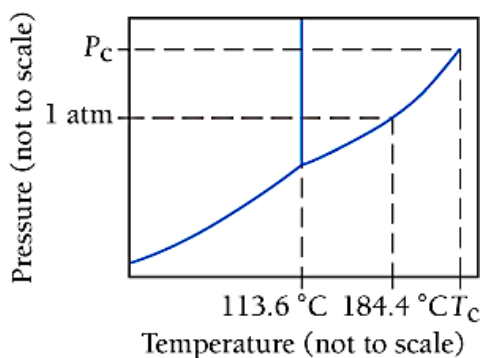
- A. 273 K
- B. 320. K
- C. 292 K
- D. 238 K
- E. 257 K

16. Using the phase diagram for phosphorous below, which of the following statements is correct? Select all that apply. Insert letters without spaces or commas, example: **ABCD**.




- A. The critical pressure and temperature of phosphorous is at 43 atm and 590 °C respectively
- B. The triple point of phosphorous is at 43 atm and 590 °C
- C. Phosphorous changes from solid to liquid to gas as you follow along the line AB
- D. Phosphorous changes from liquid to gas to solid as you follow along the line AB
- E. Phosphorous exists as a gas if it is heated at 22 atm and 750 °C

17. Using the phase diagram for iodine below, answer the following questions:



A. What is the normal boiling point for iodine?

 °C

B. What is the normal melting point for iodine?

 °C

C. Which physical state is present at 186 °C and 1.0 atm? (Insert: solid, liquid, or gas).

**Extra Practice Questions: these questions will not be graded.**

1. You purchase a new pressure cooker, and the instruction booklet specifies that the “highest setting” is 0.745 atm. You already know that standard atmospheric pressure is 1.00 atm, so the instruction booklet must mean 0.745 atm above atmospheric pressure. At what temperature in degree Celsius will water boil in this pressure cooker if it is programmed on the highest setting? ( $\Delta H_{\text{vap}}$  for water = 40.7 kJ/mol)

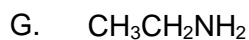
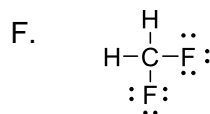
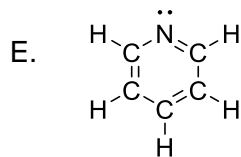
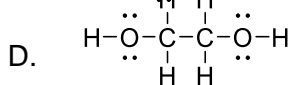
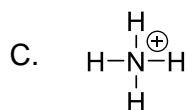
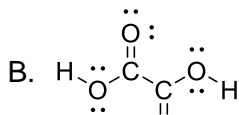
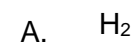
 °C

2. A hypothetical substance "Honorium" has a melting point of  $-10.0\text{ }^{\circ}\text{C}$  and a boiling point of  $155\text{ }^{\circ}\text{C}$ . If the "Honorium" is heated from  $2\text{ }^{\circ}\text{C}$  to the gas phase at  $155\text{ }^{\circ}\text{C}$ , which of these would be used to calculate the total heat added?

- i. Specific heat of the solid phase
- ii. Heat of fusion
- iii. Specific heat of the liquid phase
- iv. Heat of vaporization
- v. Specific heat of the gas phase

- A. i, ii, iii, iv, and v
- B. i and ii only
- C. iii, iv, and v
- D. iii and iv only
- E. ii, iii, and iv
- F. ii and iii only

3. Which of the following pure substances would be capable of hydrogen bonding? Select all that apply.



4. The molar mass and boiling point of three compounds is provided in the table below. Answer the questions based on the tabulated data.

	<b>Compound</b>	<b>Molar Mass (g/mol)</b>	<b>Boiling Point (°C)</b>
A.	2-hexanone	100.16	128
B.	heptane	100.20	98
C.	1-hexanol	102.17	156

- I. Which compound do you expect to form hydrogen bonding?

- II. Which compound do you expect to be polar but NOT capable of forming hydrogen bonding?

- III. Which compound do you expect to be neither polar nor capable of forming hydrogen bonding?

5. If you have a closed container with a liquid and the liquid is heated, which of the following you would not expect to happen?

- A. The molecules of the liquid and vapor phase move faster
- B. The vapor pressure increases with temperature
- C. The densities of the liquid and vapor phase become the same
- D. The molecules in the vapor phase and the surface of the liquid phase are in dynamic equilibrium
- E. The liquid will boil at its boiling point

## Formula Sheet

### Length

1 kilometer = 0.62137 mile  
1 inch = 2.54 centimeters (exactly)  
1 Ångstrom =  $1 \times 10^{-10}$  meter

### Energy

1 joule =  $1 \text{ kg} \cdot \text{m}^2 / \text{s}^2$   
1 calorie = 4.184 joules  
1 Calorie = 1 kilocalorie = 1000 calories  
1 L·atm = 101.325 joules

### Pressure

1 pascal =  $1 \text{ N} / \text{m}^2 = 1 \text{ kg} / \text{m} \cdot \text{s}^2$   
1 atmosphere = 101.325 kilopascals = 760 mm Hg = 760 torr = 14.70 lb/in<sup>2</sup>  
1 bar =  $1 \times 10^5$  Pa (exactly)

### Temperature

0 K = -273.15°C  
K = °C + 273.15  
°C = (5/9)(°F - 32)

### Mass

1 kg = 2.205 lbs

### Volume

1 mL =  $1 \text{ cm}^3 = 1 \text{ cc}$

### Constants

$c = 2.998 \times 10^8 \text{ m/sec}$   
 $h = 6.626 \times 10^{-34} \text{ J} \cdot \text{sec}^{-1}$   
 $R = 0.08206 \text{ L} \cdot \text{atm} / \text{mol} \cdot \text{K} = 8.314 \text{ J} / \text{mol} \cdot \text{K}$   
Specific heat of water = 4.184 J/g·K  
Mass of an electron:  $9.109 \times 10^{-31} \text{ kg}$   
Mass of a proton:  $1.673 \times 10^{-27} \text{ kg}$   
 $RH = 2.18 \times 10^{-18} \text{ J}$   
Specific heat of water = 4.184 J/g·K  
STP = 273.15 K and 1 atm  
Avogadro's number:  $6.022 \times 10^{23}$

### Equations

$d \text{ (density)} = m/V$   
 $P_1 V_1 = P_2 V_2$   
 $V_1/T_1 = V_2/T_2$   
 $P_1 V_1/n_1 T_1 = P_2 V_2/n_2 T_2$   
 $PV = nRT$   
 $(P + a(n^2/V^2)) \cdot (V - nb) = nRT$   
molar mass (M) =  $mRT/PV$   
density (d) =  $MP/RT$   
 $x_A = n_A/n_{\text{tot}} = P_A/P_{\text{tot}} = V_A/V_{\text{tot}}$   
 $P_{\text{tot}} = P_A + P_B + \dots$   
 $n_{\text{tot}} = n_A + n_B + \dots$

$$\mu_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\frac{\text{Rate of effusion A}}{\text{Rate of effusion B}} = \sqrt{\frac{MW_B}{MW_A}}$$

$$Q = C \times \Delta T = c_{\text{specific}} \times m \times \Delta T$$

$$Q = n \times \Delta H \text{ (kJ/mol)} = m \times \Delta H \text{ (kJ/g)}$$

$$w = -P\Delta V$$

$$\Delta E = q + w$$

$$\Delta H^\circ = \sum n\Delta H_f^\circ(\text{products}) - \sum n\Delta H_f^\circ(\text{reactants})$$

$$\Delta H^\circ = \sum n\Delta H^\circ(\text{bonds broken}) - \sum n\Delta H^\circ(\text{bonds formed})$$

$$E = h\nu$$

$$c = \lambda\nu$$

$$\lambda = h/mv$$

$$\Delta E = -2.18 \times 10^{-18} J \left( \frac{1}{n_f^2} - \frac{1}{n_i^2} \right)$$

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

$$C_g = kP_g$$

$$P_{\text{solution}} = P_{\text{solvent}} X_{\text{solvent}}$$

$$P_{\text{solution}} = \sum P_j = \sum P_j X_j$$

$$\Delta T_b = K_b m_i$$

$$\Delta T_f = K_f m_i$$

$$\pi = MRTi$$

### Thermodynamic and Electrochemistry

$$S = k_b \times \ln(W)$$

$$k_b = 1.381 \times 10^{-23} \text{ J/K}$$

$$\Delta S = q_{\text{rev}}/T$$

$$\Delta S_{\text{surr}} = q_{\text{surr}}/T = -q_{\text{rev}}/T$$

$$\Delta S_{\text{univ}} = \Delta S_{\text{sys}} + \Delta S_{\text{surr}}$$

$$\Delta S^\circ_{\text{rxn}} = \sum \nu S^\circ_{\text{products}} - \sum \nu S^\circ_{\text{reactants}}$$

$$\Delta H^\circ_{\text{rxn}} = \sum \nu H^\circ_{\text{products}} - \sum \nu H^\circ_{\text{reactants}}$$

$$\Delta G^\circ_{\text{rxn}} = \sum \nu G^\circ_{\text{products}} - \sum \nu G^\circ_{\text{reactants}}$$

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

$$\Delta G = \Delta G^\circ + RT \cdot \ln Q$$

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

$$\Delta G^\circ = -RT \cdot \ln K$$

$$\Delta G = -nFE_{\text{cell}}$$

$$F = 96485 \text{ J/(V}\cdot\text{mol e}^-)$$

$$E^\circ_{\text{cell}} = RT/nF \ln K$$

$$E^\circ_{\text{cell}} = (0.0257/n) \ln K = (0.0592/n) \log K$$

$$E_{\text{cell}} = E^\circ_{\text{cell}} - (RT/nF) \ln Q$$

$$E_{\text{cell}} = E^\circ_{\text{cell}} - (0.0257/n) \ln Q$$

$$\text{Electrolysis: } Q \text{ (total charge)} = I \times t = n \times F$$

### Integrated Rate Laws & half-life

$$\ln \frac{[A]}{[A]_0} = -kt$$

$$\frac{1}{[A]} = kt + \frac{1}{[A]_0}$$

$$[A] = -kt + [A]_0$$

$$t_{1/2} = \frac{[A]_0}{2k}$$

$$t_{1/2} = \frac{\ln 2}{k} = \frac{0.693}{k}$$

$$t_{1/2} = \frac{1}{k[A]_0}$$

$$\ln \frac{k_2}{k_1} = -\frac{E_a}{R} \left( \frac{1}{T_2} - \frac{1}{T_1} \right)$$

### **Equilibrium and Acid / Base**

$$K_p = K_c \times (RT)^{\Delta n}$$

$$\text{pH} = -\log[\text{H}_3\text{O}^+]$$

$$K_w = 1.0 \times 10^{-14} \text{ at } 25^\circ\text{C}$$

$$K_w = [\text{H}_3\text{O}^+] \times [\text{OH}^-]$$

$$K_w = K_a \times K_b$$

$$\text{p}K_a = -\log[K_a]$$

$$\text{Buffer: pH} = \text{p}K_a + \log \frac{[\text{A}^-]}{[\text{HA}]}$$

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



# Periodic Table of the Elements

1																		18																	
1 H 1.01																2 He 4.00																			
3 Li 6.94																10 Ne 20.18																			
4 Be 9.01																9 F 19.00																			
11 Na 22.99																18 Ar 39.95																			
12 Mg 24.31																17 Cl 35.45																			
																16 S 32.06																			
																15 P 30.97																			
																14 Si 28.09																			
																13 Al 26.98																			
																12 Zn 65.38																			
																11 Cu 63.55																			
																10 Ni 58.69																			
																9 Co 58.93																			
																8 Fe 55.85																			
																7 Mn 54.94																			
																6 Cr 52.00																			
																5 V 50.94																			
																4 Ti 47.87																			
																3 Sc 44.96																			
																2 Ca 40.08																			
																19 K 39.10																			
37 Rb 85.47		38 Sr 87.62		39 Y 88.91		40 Zr 91.22		41 Nb 92.91		42 Mo 95.95		43 Tc [97]		44 Ru 101.07		45 Rh 102.91		46 Pd 106.42		47 Ag 107.87		48 Cd 112.41		49 In 114.82		50 Sn 118.71		51 Sb 121.76		52 Te 127.60		53 I 126.90		54 Xe 131.29	
37 Cs 132.91		56 Ba 137.33																				86 Rn [222]													
72 Hf 178.49		73 Ta 180.95		74 W 183.84		75 Re 186.21		76 Os 190.23		77 Ir 192.22		78 Pt 195.08		79 Au 196.97		80 Hg 200.59		81 Tl 204.38		82 Pb 207.2		83 Bi 208.98		84 Po [209]		85 At [210]		118 Og [294]							
104 Rf [267]		105 Db [268]		106 Sg [269]		107 Bh [270]		108 Hs [269]		109 Mt [277]		110 Ds [281]		111 Rg [282]		112 Cn [285]		113 Nh [286]		114 Fl [290]		115 Mc [290]		116 Lv [293]		117 Ts [294]									
87 Fr [223]		88 Ra [226]																																	
57 La 138.91		58 Ce 140.12		59 Pr 140.91		60 Nd 144.24		61 Pm [145]		62 Sm 150.36		63 Eu 151.96		64 Gd 157.25		65 Tb 158.93		66 Dy 162.50		67 Ho 164.93		68 Er 167.26		69 Tm 168.93		70 Yb 173.05		71 Lu 174.97							
89 Ac [227]		90 Th 232.04		91 Pa 231.04		92 U 238.03		93 Np [237]		94 Pu [244]		95 Am [243]		96 Cm [247]		97 Bk [247]		98 Cf [251]		99 Es [252]		100 Fm [257]		101 Md [258]		102 No [259]		103 Lr [262]							