**MULTIPLE CHOICE (3pts each): Write the ONE letter corresponding to the correct answer on the line next to each question. The LETTER ASSOCIATED WITH THE CORRECT ANSWER MUST BE WRITTEN ON THE LINE NEXT TO THE QUESTION in order to receive full credit.**

1.) Which intermolecular attractive force would play a large role in the folding of proteins that have $-NH_2$ groups on their side chains? 1.) __B__

a. ) dispersion forces
b.) hydrogen bonds
c.) dipole-dipole interactions
d.) ionic bonds

2.) For the reaction $N_2 + 3H_2 \dashrightarrow 2NH_3$, if at one instant in time the rate of disappearance of $H_2$ is 0.210 M/s, what is the rate of appearance of $NH_3$ at that time? 2.) __D__

a.) 0.315 M/s
b.) 0.210 M/s
c.) 0.420 M/s
d.) 0.140 M/s

$0.210\ M/s\left(2NH_3/3H_2\right) =$

3.) What is the osmotic pressure exerted by a 0.561 M solution of glucose at 25°C? $+273.15$ 3.) __A__

a.) 13.7 atm
b.) 1.15 atm
c.) 1390 atm
d.) 117 atm

$\Pi = (1)(0.561\ M)(0.08206\ \frac{L\ atm}{mol\ K})(298.15\ K)$

4.) The smaller component of a solution is referred to as the 4.) __C__

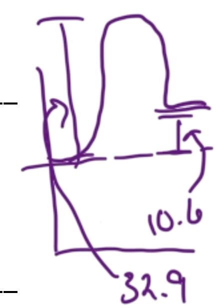
a.) precipitate
b.) solvent
c.) solute
d.) saturate

5.) Which of the following compounds is most likely to be soluble in water? ← H bond 5.) __D__

a. ) $C_6H_{12}$ dispersion
b.) $H_{11}C_5-O-C_5H_{11}$ dipole-dipole
c.) $CH_4$ dispersion
d.) $H_5C_2-O-H$ ← H bonding

6.) The theoretical van't Hoff factor for $Sn(NO_3)_2$ is 6.) __C__

a.) 1
b.) 2
c.) 3
d.) 4




7.) In a given reaction, the activation energy is 32.9 kJ/mol and the energy of the overall reaction is +10.6 kJ/mol. What is the activation energy of the reverse reaction? Drawing an Energy Diagram may help you to answer this question. 7.) __B__

a.) 43.5 kJ/mol
b.) 22.3 kJ/mol
c.) 32.9 kJ/mol
d.)349 kJ/mol

endothermic $32.9 - 10.6 = 22.3$

8.) For a given reaction, the rate law is: rate = 0.857 $M^{-2}s^{-1}$ $[A]^2[B]$. What is the rate when the concentration of A is 0.52M and the concentration of B is 0.88M? 8.) __A__

a.) 0.20 M/s
b.) 0.39 M/s
c.) 0.28 M/s
d.) 3.6 M/s

$rate = (0.857\ M^{-2}s^{-1})(0.52M)^2(0.88M) = 0.2039\ M/s$

9.) Which of the following would cause the greatest increase of the reaction rate of two solid compounds dissolved in a liquid? 9.) __B__

a.) decrease concentration
b.) increase temperature
c.) increase pressure ← only impacts gases
d.) all responses would increase this rate

10.) What is the half life of a zero order reaction with a rate constant of 0.256$M^{-1}s^{-1}$ when the initial concentration is 1.765 M 10.)__D__

a.) 2.21 s
b.) 2.71 s
c.) 0.226 s
d.) 3.45 s

$$t_{1/2} = \frac{[A]_0}{2k} = \frac{1.765M}{2(0.256M^{-1}s^{-1})}$$

$$= 3.447 s$$

**SHORT ANSWER (10 pts each): Completely answer all of the following questions. Read all questions carefully!!! ALL WORK MUST BE SHOWN TO RECEIVE FULL CREDIT. If your work is in a different location, you must make a note of this in the given work area for the problem in order for the work to be considered for partial credit. Make sure to include units and report all mathematical answers to the correct number of significant figures. Write final answers in designated locations when indicated.**

1.) a.) What is the molality of a 2.17 M aqueous solution of $MgCl_2$ (MM: 95.211 g/mol) if the density of the solution is 1.863 g/mL?

use 1.000 L soln = 2.17 mol

$1 L = 1000 mL \left(\frac{1.863 g}{mL}\right) = 1.863 g$ soln

Answer: 1.31 m

$2.17 mol \left(\frac{95.211 g}{mol}\right) = 206.61 g$ solute

1.863 g soln − 206.61 g solute = 1656.39 g solvent = 1.65639 kg

$m = \frac{mol}{kg} = \frac{2.17 mol}{1.65639 kg} = 1.31001 m$

b.) What would be the freezing point of this solution? Report your answer to two decimal places.

$MgCl_2$ $i = 3$

Answer: −7.31°C

$\Delta T = i k_f m = (3)(1.86°C/m)(1.31001 m) = 7.3102°C$

$T = 0 - 7.3102°C = -7.31°C$

2.) Given the following set of data for the reaction A + B → C:

| Experiment | [A] (M) | [B] (M) | Rate (M/s) |
|---|---|---|---|
| 1 | 0.10 | 0.10 | 2.56 |
| 2 | 0.20 | 0.10 | 5.11 |
| 3 | 0.20 | 0.20 | 10.20 |

a.) What is the order of reaction with respect to A? Answer: 1st

$\frac{Exp 2}{Exp 1}$ $\left[\frac{0.20}{0.10}\right]^m = \frac{5.11}{2.56}$ $2^m = 1.996$ $m = 1$

b.) What is the order of the reaction with respect to B? Answer: 1st

$\frac{Exp 3}{Exp 2}$ $\left[\frac{0.20}{0.10}\right]^n = \frac{10.20}{5.11}$ $2^n = 1.996$ $m = 1$

c.) What is the value of k for the reaction based on all three experiments?

rate = k[A][B] $k = \frac{rate}{[A][B]}$

Answer: $255.5 M^{-1} s^{-1}$

Exp 1: $\frac{2.56 M/s}{[0.10 M][0.10 M]} = 256 M^{-1}s^{-1}$

Exp 2: $\frac{5.11 M/s}{[0.20 M][0.10 M]} = 255.5 M^{-1}s^{-1}$

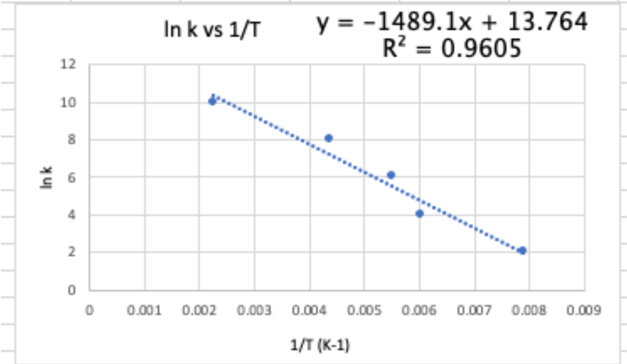
Exp 3: $\frac{10.20 M/s}{[0.20 M][0.20 M]} = 255 M^{-1}s^{-1}$

Avg: $256 M^{-1}s^{-1}$
$255.5 M^{-1}s^{-1}$
$+ 255 M^{-1}s^{-1}$
$766.5/3 = 255.5 M^{-1}s^{-1}$

d.) Write the rate law for this reaction: Rate =

Rate = $255.5 M^{-1}s^{-1}$ [A][B]

3.) a.) Use the graph below to determine the Activation Energy of the reaction.




Answer: 12.38 kJ/mol

$Ea = -\text{slope} \times R$

$= (1489.1\ K)(8.314\times10^{-3}\ kJ/mol\ K)$

$= 12.38\ kJ/mol$

b.) Use the Activation Energy from part a to answer the following question. If you did not get an answer for part a, make up a value, write it in the answer line for part a, and use that number to answer part b. Question: At 45°C, the value of k for the reaction is 0.447 $s^{-1}$. At what temperature in degrees Celsius will the value of k be three times the given k value?

Answer: 142.6°C

$\ln \frac{k_1}{k_2} = \frac{Ea}{R}\left[\frac{1}{T_2} - \frac{1}{T_1}\right]$

$k_1 = 0.447\ s^{-1}$

$k_2 = 3(0.447\ s^{-1}) = 1.341\ s^{-1}$

$45°C + 273.15 = 318.15\ K$

$\ln\left(\frac{0.447}{1.341}\right) = \frac{12.38\ kJ/mol}{8.314\times10^{-3}\ kJ/mol\ K}\left[\frac{1}{T_2} - \frac{1}{318.15\ K}\right]$

$\frac{-1.0986}{1489.1\ K} = \frac{\cancel{1489.1\ K}\left[\frac{1}{T_2} - 0.003143\ K^{-1}\right]}{\cancel{1489.1\ K}}$

$-0.00073776\ K^{-1} = \frac{1}{T_2} - \cancel{0.003143\ K^{-1}}$

$+0.003143\ K^{-1} \qquad \cancel{+0.003143\ K^{-1}}$

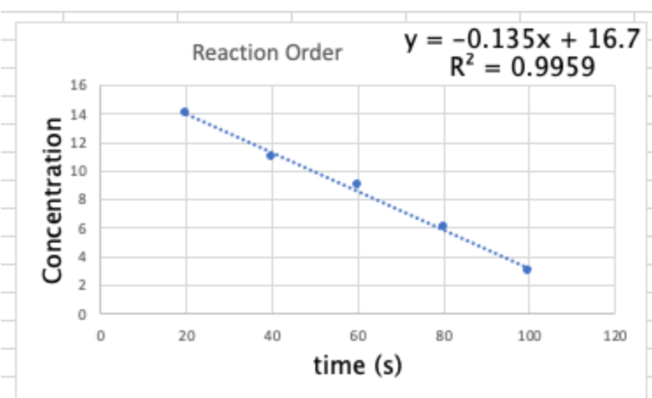
$\frac{1}{T_2} = 0.0024052\ K^{-1}$

$T_2 = \frac{1}{0.0024052\ K^{-1}}$

$= 415.766\ K - 273.15$

$= 142.616°C$

4.) Use the graph below to answer the following questions.




a.) What is the order of the reaction?

Answer: zero

b.) What is the value of k?

Answer: +0.135 M/s

c.) If the initial concentration was 2.41M, what was the concentration after 10 seconds?

Answer: 1.06 M

zero order: $[A] = -kt + [A]_0$

$[A] = -(0.135\ M/s)(10\ s) + 2.41\ M$

$= -1.35\ M + 2.41\ M$

$= 1.06\ M$

5.) A first order reaction has an initial concentration of 2.48M. After 10.0 minutes, the concentration drops to 1.76M.

a.) Calculate the rate constant. Answer: 0.343 min$^{-1}$

1st order: $\ln[A] = -kt + \ln[A]_0$

$\ln[1.76] = -(k)(10.0\text{min}) + \ln[2.48]$

$0.5653 = -(k)(10.0\text{min}) + \cancel{0.90826}$

$-0.90826 \qquad\qquad -\cancel{0.90826}$

$\dfrac{-0.34296}{-10.0\text{min}} = \dfrac{-k(\cancel{10.0\text{min}})}{-\cancel{10.0\text{min}}}$

$k = 0.034296\text{min}^{-1}$

b.) What is the half-life for this reaction? Answer: 20.2 min

$t_{1/2} = \dfrac{0.693}{k}$

$= \dfrac{0.693}{0.034296\text{min}^{-1}} = 20.206\text{min}$

6.) The reaction 2Q + P → 3W + Z has the rate law: rate = k[Q][P].

a.) Which of the following options is the most likely mechanism for this reaction?

Option 1

Step 1: Q + Q → ~~X~~ + Z rate = k[Q]$^2$

Step 2: ~~X~~ + P → 3W rate = k[X][P]

2Q + P = 3W + Z

Option 2

Step 1: Q + P → ~~X~~ + Z rate = k[Q][P]

Step 2: ~~X~~ + Q → 2W rate = k[X][Q]

no → 2Q + P → 2W + Z

Option 3

Step 1: Q + P → ~~X~~ + 2W rate = k[Q][P] ← yes

Step 2: ~~X~~ + Q → W + Z rate = k[X][Q]

2Q + P → 3W + Z

↑ yes

Option 4

Q + Q → ~~X~~ + W rate = k[Q]$^2$

~~X~~ + P → W + Z rate = k[X][P]

2Q + P → 2W + Z

no →

Answer: Option 3

b.) Briefly describe two pieces of evidence which support your answer.

(1) The steps add up to the overall balanced equation

(2) The rate for step 1 matches the rate of the overall reaction

7.) What is the vapor pressure above a solution containing 35.59g fructose (180.1559 g/mol) dissolved in 100.0g of water (18.01528 g/mol) at 20.0°C? The vapor pressure of pure water at 20°C is 17.5 torr.

Answer: 16.9 torr

$$P_a = X_a P_a^\circ$$

$$X_a = \frac{mol\ H_2O}{(mol\ H_2O + mol\ fructose)}$$

$$H_2O:\ 100.0g\left(\frac{1\ mol}{18.01528g}\right) = 5.5508\ mol$$

$$fructose:\ 35.59g\left(\frac{1\ mol}{180.1559g}\right) = 0.19755\ mol$$

$$X_a = \frac{5.5508\ mol}{(5.5508\ mol + 0.19755\ mol)} = \frac{5.5508\ mol}{5.74835\ mol} = 0.96563$$

$$P_a = (0.96563)(17.5\ torr)$$

$$= 16.8986\ torr$$