MULTIPLE CHOICE (2 pts each): Write the 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) What is the oxidation number of sulfur in H_2SO_4? 1) _____

a) +6 b) +4 c) -6 d) -4

2) The study of the speed at which reactions occur is referred to as 2) _____

a) thermodynamics b) kinetics
c) mechanistics d) linguistics

3) For the instantaneous reaction A + 2B → C + 4D, if B disappears at a rate of -5 M/s, how fast does D appear? 3) _____

a) 10 M/s b) 5 M/s c) 2.5 M/s d) 4 M/s

4) How many valence electrons are present in phosphorus? 4) _____

a) 2 b) 4 c) 3 d) 5

5) For which type of reaction is the half-life independent of initial concentration? 5) _____

a) zero order b) second order
c) first order d) third order

6) What volume would contain 15.6 g of a material with a density of 32.9 g/L? 6) _____

a) 0.474 mL b) 0.513 mL c) 513 mL d) 474 mL

7) What volume of a 15.8 M solution would you need to make 500.0 mL of a 0.700 M solution? 7) _____

a) 11.3 mL b) 22.2 mL c) 11.3 L d) 22.2 L

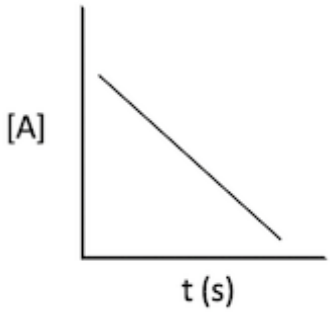
8) Which type of elementary reaction is likely to be the fastest? 8) _____

a) bimolecular b) termolecular c) unimolecular

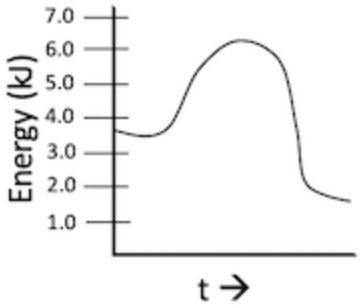
SHORT ANSWER (14 pts each): Completely answer all of the following questions. Read all questions carefully!!! Show all work. Make sure to include units and report all mathematical answers to the correct number of significant figures. Write final answers in designated locations when indicated.

1) (a) What is the order of the reaction shown in the following graph?

Answer a:_____



Use the graph below to answer the following questions.



(b) What is the activation energy of the forward reaction? Answer b:_____

(c) What is the activation energy of the reverse reaction? Answer c:_____

(d) What is the energy of the transition state? Answer d:_____

(e) Is the reaction exothermic or endothermic? Answer e:_____

(f) What is the overall energy of the reaction? Answer f:_____

(g) Add a curve to the graph representing what the energy would look like with the addition of a catalyst.

2) You conduct a series of experiments on the reaction A + B $\rightarrow$ C and obtain the following data:

	[A] (M)	[B] (M)	rate (M/s)
Expt 1	0.10	0.10	2.48×10^{-3}
Expt 2	0.10	0.20	4.96×10^{-3}
Expt 3	0.20	0.10	9.92×10^{-3}

(a) What is the order of the reaction in A? Answer a: _____

(b) What is the order of the reaction in B? Answer b:_____

(c) What is the overall reaction order? Answer c: _____

(d) What is the value of k? (make sure to show ALL work!) Answer d: _____

(e) What is the rate law for this reaction? Answer e: _____

3) (a) How many moles of H^+ are present in 25.3 mL of a 1.6M solution of phosphoric acid (H_3PO_4)?

Answer a: _____

(b) Write formulas for the following compounds:

i.) lead (II) bromide

ii.) potassium oxide

iii.) carbon tetraiodide

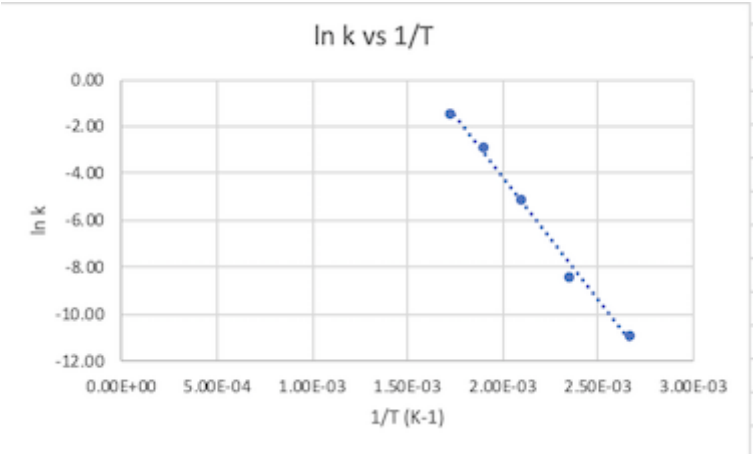
(c) Name the following compounds:

i.) $MgBr_2$

ii.) Cr_2S_3

iii.) PO_3

4) Calculate the Activation Energy for the reaction used to generate the following graph.



Answer:_____

5) a.) The reaction $A + 2B \rightarrow C$ was found to have the rate law: Rate = $k[B]^2$. The following two mechanisms have been proposed:

Mechanism 1:	Mechanism 2:
$A + B \rightarrow D$	$B + B \rightarrow D$
$D + B \rightarrow C$	$D + A \rightarrow C$

i.) Which is the correct mechanism? Answer i: _____
Briefly explain your choice.

ii.) What is the rate limiting step (write the elementary reaction)?
Answer ii:_____

iii.) What is the rate law for the rate limiting step? Answer iii:_____

b.) A reaction proceeds through two elementary steps with the following rates:

Step 1: 3.87×10^{-5} M/s
Step 2: 6.28×10^{-7} M/s

iv.) Which is the rate limiting step? Answer iv: _____
Briefly explain your answer.

v.) What is the approximate rate of the overall reaction? Answer v: _____

6) After 3600s, the concentration of a 2.5M solution has decreased to 0.86M. If the reaction is **zero** order:

(a) What is the value of k? Answer a:_____

(b) What is the half life? Answer b:_____

MULTIPLE CHOICE (2 pts each): Write the 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) What is the oxidation number of sulfur in H_2SO_4? $(+1)(2) + S + (-2)(4) = 0$ 1) A

a) +6 b) +4 c) -6 d) -4

$2 + S - 8 = 0$ $S = 6$

2) The study of the speed at which reactions occur is referred to as 2) B

a) thermodynamics b) kinetics

c) mechanistics d) linguistics

3) For the instantaneous reaction $A + 2B \rightarrow C + 4D$, if B disappears at a rate of -5 M/s, how fast does D appear? 3) A

a) 10 M/s b) 5 M/s c) 2.5 M/s d) 4 M/s

$-5\left(\frac{4}{2}\right) = -10$

4) How many valence electrons are present in phosphorus? 4) D

a) 2 b) 4 c) 3 d) 5

5) For which type of reaction is the half-life independent of initial concentration? 5) C

a) zero order b) second order

c) first order d) third order

6) What volume would contain 15.6 g of a material with a density of 32.9 g/L? 6) D

a) 0.474 mL b) 0.513 mL c) 513 mL d) 474 mL

$15.6\,g\left(\frac{1\,L}{32.9\,g}\right) = 0.474\,L\left(\frac{1000\,mL}{L}\right) = 474\,mL$

7) What volume of a 15.8 M solution would you need to make 500.0 mL of a 0.700 M solution? 7) B

a) 11.3 mL b) 22.2 mL c) 11.3 L d) 22.2 L

$(15.8\,M)(x) = (0.700\,M)(500.0\,mL)$ $x = 22.2\,mL$

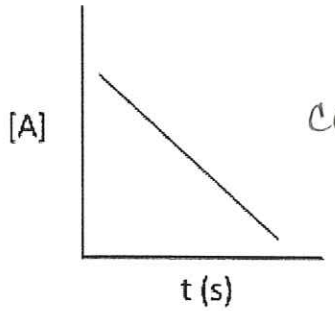
8) Which type of elementary reaction is likely to be the fastest? 8) C

a) bimolecular b) termolecular c) unimolecular

SHORT ANSWER (14 pts each): Completely answer all of the following questions. Read all questions carefully!!! Show all work. 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.

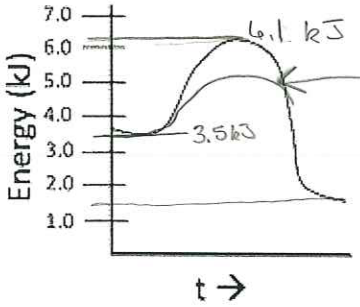
1) (a) What is the order of the reaction shown in the following graph?

Answer a: zero



conc. vs. time is linear

Use the graph below to answer the following questions.



catalyst lowers Ea

(b) What is the activation energy of the forward reaction? Answer b: 2.6 kJ

$6.1\ kJ - 3.5\ kJ = 2.6\ kJ$

(c) What is the activation energy of the reverse reaction? Answer c: 4.6 kJ

$6.1\ kJ - 1.5\ kJ = 4.6\ kJ$

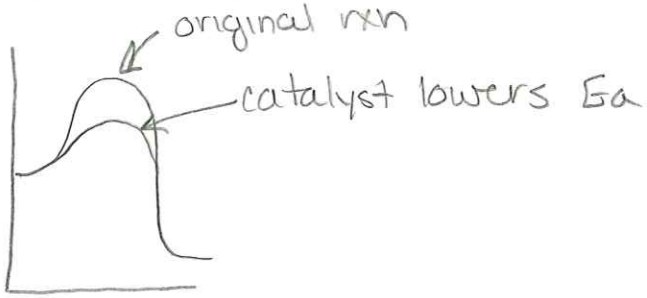
(d) What is the energy of the transition state? Answer d: 6.1 kJ

(e) Is the reaction exothermic or endothermic? Answer e: exothermic

(f) What is the overall energy of the reaction? Answer f: −2 kJ

$1.5\ kJ - 3.5\ kJ = -2\ kJ$

(g) Add a curve to the graph representing what the energy would look like with the addition of a catalyst.



2) You conduct a series of experiments on the reaction A + B → C and obtain the following data:

	[A] (M)	[B] (M)	rate (M/s)
Expt 1	0.10	0.10	2.48×10^{-3}
Expt 2	0.10	0.20	4.96×10^{-3}
Expt 3	0.20	0.10	9.92×10^{-3}

(a) What is the order of the reaction in A? Answer a: second

$$\left(\frac{[0.20M]}{[0.10M]}\right)^m = \frac{9.92 \times 10^{-3} M/s}{2.48 \times 10^{-3} M/s}$$

$2^m = 4 \quad m = 2$

(b) What is the order of the reaction in B? Answer b: first

$$\left(\frac{[0.20M]}{[0.10M]}\right)^n = \frac{4.96 \times 10^{-3} M/s}{2.48 \times 10^{-3} M/s}$$

$2^n = 2 \quad n = 1$

(c) What is the overall reaction order? Answer c: third

$2 + 1 = 3$

(d) What is the value of k? (make sure to show ALL work!) Answer d: $2.48\ M^{-2}S^{-1}$

expt 1: $2.48 \times 10^{-3} M/s = k(0.10M)^2(0.10M) \quad k = 2.48\ M^{-2}S^{-1}$

expt 2: $4.96 \times 10^{-3} M/s = k(0.10M)^2(0.20M) \quad k = 2.48\ M^{-2}S^{-1}$

expt 3: $9.92 \times 10^{-3} M/s = k(0.20M)^2(0.10M) \quad k = 2.48\ M^{-2}S^{-1}$

$7.44\ M^{-2}S^{-1} / 3 = 2.48\ M^{-2}S^{-1}$

(e) What is the rate law for this reaction? Answer e: $Rate = 2.48\ M^{-2}S^{-1}[A]^2[B]$

3) (a) How many moles of H^+ are present in 25.3 mL of a 1.6M solution of phosphoric acid (H_3PO_4)?

$\frac{1.6 \text{ mol } H_3PO_4}{L} \times 0.0253 L = 0.04048 \text{ mol } H_3PO_4 \left(\frac{3 \text{ mol } H^+}{1 \text{ mol } H_3PO_4}\right) = 0.12144 \text{ mol } H^+$

Answer a: 0.12 mol

(b) Write formulas for the following compounds:

i.) lead (II) bromide $PbBr_2$

ii.) potassium oxide K_2O

iii.) carbon tetraiodide CI_4

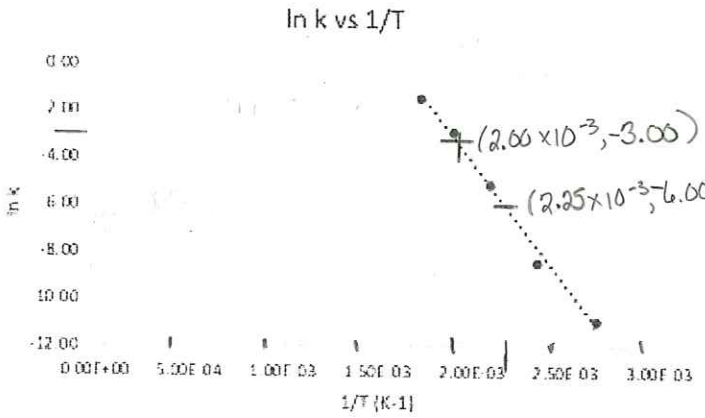
(c) Name the following compounds:

i.) $MgBr_2$ Magnesium bromide

ii.) Cr_2S_3 Chromium (III) sulfide

iii.) PO_3 Phosphorus trioxide

4) Calculate the Activation Energy for the reaction used to generate the following graph.



$\frac{-6.00-(-3.00)}{(2.25\times10^{-3}\text{K} - 2.00\times10^{-3}\text{K})} = \frac{-3.00}{2.5\times10^{-4}\text{K}}$

$= -12{,}000 \text{ K}$

Slope $= -Ea/R$ $\quad Ea = -\text{slope} \times R$

$Ea = 12{,}000 \text{ K} \times 8.314 \text{ J/mol K}$

$= 99{,}768 \text{ J/mol}$

Answer: 99,800 J/mol

or 9.98×10^4 J/mol

or 99.8 kJ/mol

(Any graphs on your exam will hopefully be easier to read)

With a graph this unclear, grade would be based on process not numerical answer.

5) a.) The reaction $A + 2B \rightarrow C$ was found to have the rate law: Rate = $k[B]^2$. The following two mechanisms have been proposed:

Mechanism 1:
$A + B \rightarrow D$ ⇒ Rate = $k[A][B]$
$D + B \rightarrow C$ ⇒ Rate = $k[D][B]$

Mechanism 2:
$B + B \rightarrow D$ ⇒ Rate = $k[B]^2$
$D + A \rightarrow C$ ⇒ Rate = $k[D][A]$

i.) Which is the correct mechanism? Answer i: Mechanism 2
Briefly explain your choice.
Must have a step w/ Rate = $k[B]^2$

ii.) What is the rate limiting step (write the elementary reaction)?
Answer ii: B + B → D

iii.) What is the rate law for the rate limiting step? Answer iii: Rate = $k[B]^2$

b.) A reaction proceeds through two elementary steps with the following rates:

Step 1: 3.87×10^{-5} M/s
Step 2: 6.28×10^{-7} M/s

iv.) Which is the rate limiting step? Answer iv: step 2
Briefly explain your answer.
slower step is rate limiting

v.) What is the approximate rate of the overall reaction? Answer v: 6.28×10^{-7} M/s

6) After 3600s, the concentration of a 2.5M solution has decreased to 0.86M. If the reaction is **zero** order:

(a) What is the value of k? Answer a: 4.6×10^{-4} M/s

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

$[0.86M] = -k(3600s) + [2.5M]$
$-2.5M \qquad -2.5M$
$\frac{-1.64M}{-3600s} = \frac{-k(3600s)}{-3600s}$ $\quad k = 4.556 \times 10^{-4}$ M/s

(b) What is the half life? Answer b: 2700 s

Zero order: $t_{1/2} = \frac{[A]_0}{2k} = \frac{[2.5M]}{2(4.556 \times 10^{-4} M/s)}$

$= \frac{2.5 M}{9.111 \times 10^{-4} M/s}$

$= 2744$ s

2.7×10^3 s