AP Exam Review 2020 Practice Exam #4

This question has two parts. The first part should take you 25 minutes to complete. The second part will take 15 minutes. Do the first question setting a timer for 25 minutes. Upon either completion of the question or the end of time, take a five minute break. Reset the timer for 15 minutes and begin the second question. Stop working when the timer goes off or you finish the question. Upload your work when completed.

Problem 1

The table below represents data for two common types of organic molecules: aldehydes and ketones.

IUPAC Name	Common Name	Structural Formula	Boiling Point (°C)	Solubility (g/100 g water)
Methanal	Formaldehyde	$HCHO$	−21	infinite
Ethanal	Acetaldehyde	CH_3CHO	20	infinite
Propanal	Propionaldehyde	CH_3CH_2CHO	49	16
Butanal	Butyraldehyde	$CH_3CH_2CH_2CHO$	76	7
Hexanal	Caproaldehyde	$CH_3(CH_2)_4CHO$	129	slight
Propanone	Acetone	CH_3COCH_3	56	infinite
2-Butanone	Methyl ethyl ketone	$CH_3COCH_2CH_3$	80	26
3-Pentanone	Diethyl ketone	$CH_3CH_2COCH_2CH_3$	101	5

a) Explain the trend in boiling points for methanal, ethanal, and propanal. Describe the type(s) of intermolecular forces in each molecule in your answer.

b) What type of intermolecular interaction accounts for the solubility of methanal in water?

Bond	Energy (kJ/mol)
C-O	358
H-O	463
C-C	348
C=O	799
C-H	413
O=O	495

c) Using the data in the table to the left, determine the heat of reaction for the combustion of methanal.

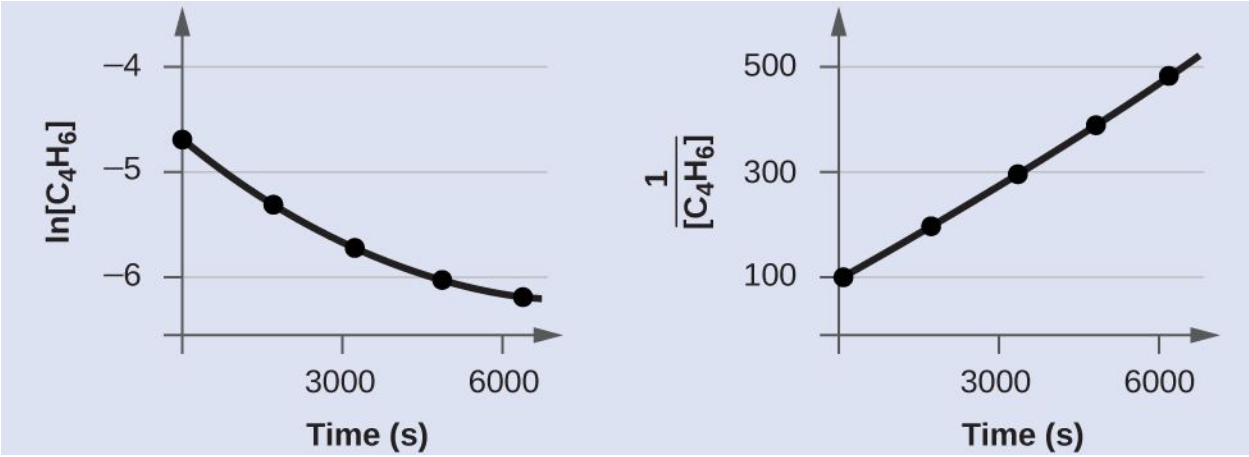
$$HCHO + O_2 \rightarrow CO_2 + H_2O$$

d) Of the bonds listed in the table, which is the longest. Justify your choice.

e) If 10.0 g of methanal is placed in a container with 10.0 g of oxygen, which reactant runs out if the reaction above goes to completion? Justify your answer with a calculation.

f) If 10.0 g of methanal is placed in a container with 10.0 g of oxygen and completely reacts, what will be the final pressure if the reaction takes place in a 2.0 L vessel and is cooled after combustion to 25 ℃.

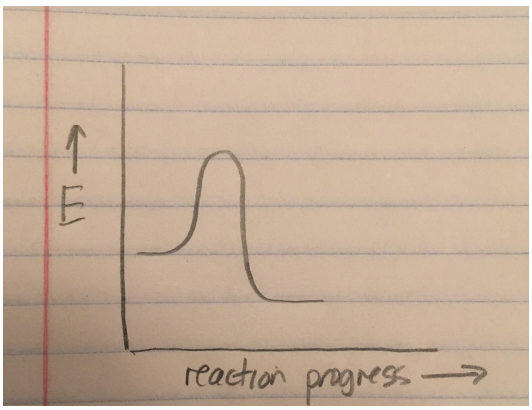
Problem 2



The graphs above were obtained for the reaction below. You can assume this is a single step reaction for the purposes of this question.

$2\ C_4H_6\ (g) \rightarrow C_8H_{12}\ (g)\quad \Delta H = \text{(negative value)}$

a) Write the rate law for this reaction and justify your choice.
b) Explain using the information given above, how you can obtain the rate constant, k.
c) Give two examples of how the graph below matches the information given above.



Atomic chlorine in the atmosphere reacts with ozone in the following pair of elementary reactions:

Step 1 $Cl\ (g) + O_3\ (g) \rightarrow ClO\ (g) + O_2\ (g)$ Slow

Step 2 $ClO\ (g) + O \rightarrow Cl\ (g) + O_2\ (g)$ Fast

d) Identify the intermediate(s) in this mechanism.
e) Identify the catalyst(s) in this mechanism.
f) Write the overall reaction equation based on this mechanism.
g) Which step has the highest activation energy? Explain.

Practice
Exam #4

1a The BP of propanol > ethanol > methanol. All three molecules are polar and have dipole-dipole attractions. They also experience LDF's. The dipoles are about the same as each molecule has the same CHO structure. What makes the difference is the size of each molecule. More atoms = more e^- = greater polarizability = stronger LDF's = greater BP.

b) Methanol molecules can H-bond to water.

c) $H-C(H)(H)-H + O=O \rightarrow O=C=O + H-O-H$

H-C	413	C=O	799
C=O	799	C=O	799
H-C	413	H-O	463
O=O	495	H-O	463
	2120 kJ		2524 kJ

$\Delta H_{rx} = \sum$ Bond Energy Reactants $- \sum$ Bond Energy Products

$= 2120\ kJ - 2524\ kJ = -404\ kJ$

d) C–C is the longest as it has the lowest Bond Energy and is a combo of the 2 largest atoms of C, H, O.

e) $10.0\,g\ HCHO \times \frac{1\ mol\ HCHO}{30.0\,g}$

$= 0.333\ mol\ HCHO$

$10.0\,g\ O_2 \times \frac{1\ mol\ O_2}{32.0\,g\ O_2}$

$= 0.313\ mol\ O_2$

O_2 runs out since mole ratio is 1:1 in the reaction, least mole runs out 1st.

OR

$0.333\ mol\ HCHO \times \frac{1\ mol\ O_2}{1\ mol\ HCHO} =$

$0.333\ mol\ O_2$ needed

Less O_2 is available than needed so O_2 runs out.

f)

	$HCHO$	$+ O_2$	$\rightarrow CO_2$	$+ H_2O$
I	0.333	0.313	0	0
C	−0.313	−0.313	+0.313	+0.313
F	0.020	0	0.313	0.313

$n_T = 0.020 + 0.313 + 0.313$

$= 0.646$ moles

$$P = \frac{nRT}{V} = \frac{(0.646)(0.0821)(298)}{(2.0)}$$

$= 7.9$ atm

2a) Rate $= k[C_4H_6]^2$, $\frac{1}{[C_4H_6]}$ graph is linear

b) k = slope of $\frac{1}{[C_4H_6]}$ vs t graph.

c) It is stated that the reaction occurs in a single step, so the graph shows one "bump" giving the E_a for that one step. The E value for the end of the graph is lower than the start indicating the reaction is exothermic.

d) ClO

e) Cl

f) $O_3 + O \rightarrow 2O_2$

g) Step 1 has the highest E_a as it is identified as the slow step. Slow step = highest E_a.