SCH 4U - EXAM REVIEW

UNIT 1 - ORGANIC CHEMISTRY

1. a) hydroxyl group
   b) double bond and amine group
   c) double bond and ester group
   d) triple bond, carbonyl group (ketone), ether group

2. a) amine
   b) alkane
   c) aldehyde
   d) ester
   e) carboxylic acid
   f) ketone

3. a) secondary
   b) tertiary
   c) primary
   d) secondary

4. a) primary
   b) secondary
   c) tertiary
   d) tertiary

5. a) 2-bromopropane
   b) cyclopentanol
   c) pentanoic acid
   d) ethyl propanoate
   e) 5-ethyl-5,6-dimethyl-3-heptanone
      or
      hepta-3-one

6. a) 3,5,7 - trimethylcycloheptene (cycloalkene)

b) 3 - ethyl - 2 - hexanol (alcohol)

c) 1 - ethyl - 4 - methylbenzene (para - ethyl methyl benzene)
(aromatic hydrocarbon)

d) 2 - methyl pentanoic acid ; carboxylic acid

e) N - ethyl - N - methyl - 1 - butanamine ; amine

f) N - butyl propanamide ; amide

7. a) $CH_3-CH_2-CH_2-NH_2$

b) $CH_3-CH_2-\overset{\overset{CH_2-CH_3}{|}}{CH}-CH_2-CH_3$

c) $CH_3-CH_2-CH_2-\overset{\overset{OH}{|}}{CH}-CH_2-CH_2-CH_3$

d) $CH_3-CH_2-\overset{\overset{O}{\|}}{C}-OH$

e)
$$\begin{array}{ccc} OH & & \\ | & & \\ CH & - & CH_2 \\ | & & | \\ CH_2 & - & CH_2 \end{array}$$

f) $CH_3-O-CH_2-CH_3$

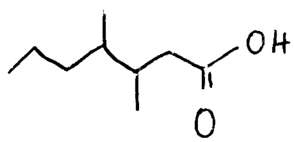
g) $Br-\overset{\overset{Br}{|}}{CH}-CH_2-CH_2-CH_3$

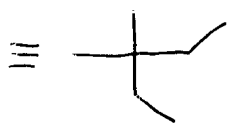
h) $CH_3-\underset{\displaystyle CH_3}{\underset{|}{CH}}-\overset{\displaystyle O}{\overset{\|}{C}}-CH_2-CH_2-CH_2-CH_2-CH_3$

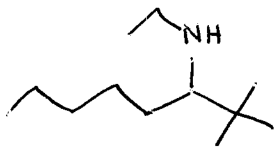
i) $CH_3-CH_2-CH_2-CH_2-CH_2-\overset{\displaystyle O}{\overset{\|}{C}}H$

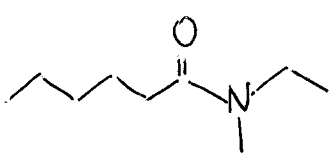
j) $CH_3-CH_2-\overset{\displaystyle O}{\overset{\|}{C}}-NH-CH_2-CH_3$

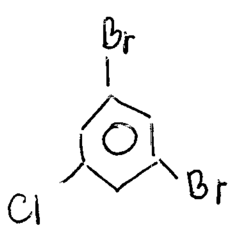
k) $CH_3-CH_2-CH_2-\overset{\displaystyle O}{\overset{\|}{C}}-O-CH_3$

8. a) 

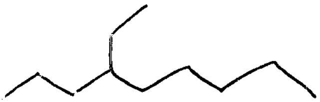
b) 

c) 

d) 

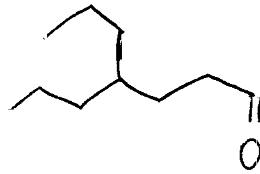
e) 

9. a)



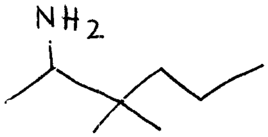
alkane

b)



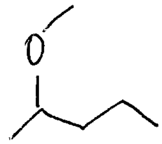
aldehyde

c)



amine

d)



ether

e)

aromatic hydrocarbon

10. a) 1-pentanal or pentanal. The -COH must be at the beginning of the molecule

b) Pentane. 1,3-dimethylpropane has a methyl group on the 1st and 3rd carbon atoms, making the chain 5 carbons long.

c) It should be 1,2-dimethylbenzene. You cannot have 2 groups on a carbon atom in benzene.

d) The N atom can only form 3 bonds, so it should be N-ethyl-N-methylpentanamide.

e) The methyl group can be on 2nd (or later) carbon atom 2-methylpropanoic acid.

11.

a)

$CH_2 = CH - CH_2 - CH_2 - CH_2 - CH_3$

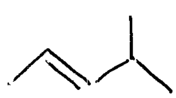
$CH_3 - CH = CH - CH_2 - CH_2 - CH_3$

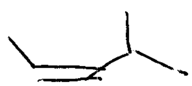
$CH_3 - CH_2 - CH = CH - CH_2 - CH_3$

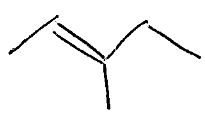
$$\begin{array}{c} \qquad\qquad\qquad\qquad\quad CH_3 \\ \qquad\qquad\qquad\qquad\quad | \\ CH_2 = CH - CH_2 - CH - CH_3 \end{array}$$

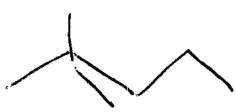
$$\begin{array}{c} \qquad\qquad\quad CH_3 \\ \qquad\qquad\quad | \\ CH_2 = CH - C - CH_3 \\ \qquad\qquad\quad | \\ \qquad\qquad\quad CH_3 \end{array}$$

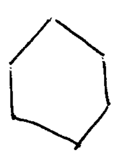
b)











12.

a) In an addition reaction, atoms are added to a double or triple bond

b) In a substitution reaction, a hydrogen atom or functional group is replaced by a different atom or functional group

c) In an elimination reaction, atoms are removed from a molecule and a double bond is formed

d) In the oxidation of an organic compound, a carbon atom forms more bonds to O and less bonds to H

e) In the reduction reaction, a C atom forms fewer bonds to O and more bonds to H

f) In a condensation reaction, two organic molecules combine to form a single organic molecule.

g) In a hydrolysis reaction, water adds to a bond and splits it in two

13. a) addition
b) substitution
c) elimination
d) substitution
e) addition
f) addition
g) substitution

14. a) Addition polymerization is a reaction in which monomers with double bonds are joined together through multiple addition reactions to form a polymer

b) Condensation polymerization is a reaction in which monomers are joined together by the formation of an ester or amide bonds Water is usually the second product.

15.

a) Markovnikov's rule states that the halide atom or OH group in an addition reaction is usually added to the more substituted carbon atom. ("rich gets richer") It applies to the following situation because the reactants are assymetrical

b) $CH_3-CH_2-CH_2-Br$ + $CH_3-CH(Br)-CH_3$

1- bromopropane   2- bromopropane

c) 2- bromopropane

16\.

a) A protein is a natural polymer made up of amino acids
Amino acids are the building brocks, or monomers, for proteins

b) Much of the body's structure is made from proteins
Proteins are also responsible for many of the biological functions in the body. Insulin is an example of a protein that helps regulate glucose levels in the body.

17\. a) Lipids are biological molecules that are not soluble in water, but are soluble in non-polar solvents

b) glycerol triolate, cholesterol, testosterone...

c) meat, milk, butter, cheese..

d) Lipids are important for the long-term storage of energy in the body. They make up cell membranes and act as hormones They also make up some of the fat-soluble vitamins, such as vitamins, A, D and E.

18\. a) A monosaccharide is a simple sugar made of one saccharide unit. A disaccharide contains two saccharide units. A polysaccharide is a polymer unit that contains many saccharide units

b) monosaccharide - glucose
disaccharide - sucrose
polysaccharide - cellulose

c) Carbohydrates are the primary source of energy for the body

19.

a) $CH_3CH=CHCH_3 + Br_2 \rightarrow CH_3-CH(Br)-CH(Br)-CH_3$

2,3-dibromobutane

b) $HO-CH_2CH_2CH_2CH_2CH_3 + HBr \rightarrow CH_3CH_2CH_2CH_2CH_2Br + H_2O$

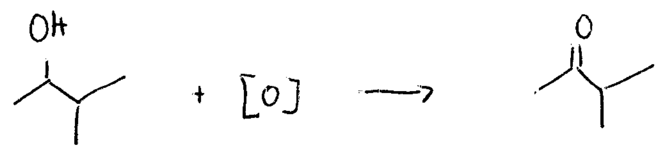
1-bromopentane

c) $CH_3CH_2\overset{O}{\overset{\|}{C}}H + [O] \rightarrow CH_3-CH_2-\overset{O}{\overset{\|}{C}}-OH$

propanoic acid

d) $HO-CH_2CH_2CH_3 \xrightarrow[\Delta]{H_2SO_4} CH_2=CH-CH_3 + H_2O$

propene

e) 

3-methyl-2-butanone

f) $CH_3CH_2\overset{O}{\overset{\|}{C}}OH + HOCH_3 \xrightarrow{H_2SO_4} CH_3-CH_2-\overset{O}{\overset{\|}{C}}-O-CH_3 + H_2O$

methyl propanoate

g) $CH_3CH=CHCH_2CH_3 + H_2 \rightarrow CH_3CH_2CH_2CH_2CH_3$

pentane

h) $CH_3-\overset{O}{\overset{\|}{C}}-O-CH_2CH_3 + H_2O \xrightarrow[\Delta]{H_2SO_4} CH_3-\overset{O}{\overset{\|}{C}}-OH + CH_3-CH_2-OH$

ethanoic acid, ethanol

20.

a) $CH_3CH_2-\overset{\overset{O}{\|}}{C}-OH + CH_3CH_2CH_2OH \rightarrow CH_3CH_2-\overset{\overset{O}{\|}}{C}-O-CH_2CH_2CH_3 + H_2O$

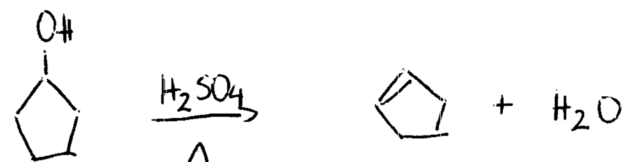
propyl propanoate

b) $CH_3CH_2C\equiv CH + Cl_2 \rightarrow$ (i) $CH_3CH_2\overset{Cl}{\overset{|}{C}}=\overset{Cl}{\overset{|}{C}}H$

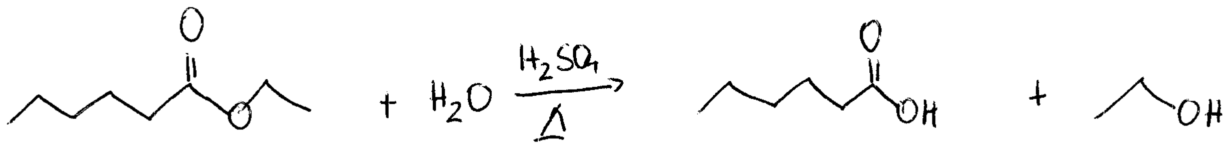
1,2-dichloro-1-butene

(ii) $CH_3CH_2-\underset{Cl}{\overset{Cl}{C}}-\underset{Cl}{\overset{Cl}{C}}H$

1,1,2,2-tetrachlorobutane

c) 

cyclopentene

d) 

hexanoic acid   ethanol

e) $CH_3-\overset{\overset{O}{\|}}{C}-\underset{CH_3}{CH}-CH_3 + [H] \rightarrow CH_3-\overset{OH}{CH}-\underset{CH_3}{CH}-CH_3$

3-methyl-2-butanol

f) $H_2C=CHCH_2CH(CH_3)_2 + HOH$

and

MAJOR $CH_3-\overset{OH}{CH}-CH_2-\underset{CH_3}{CH}-CH_3$

4-methyl-2-pentanol

$\overset{OH}{CH_2}-CH_2-CH_2-\underset{CH_3}{CH}-CH_3$ MINOR

4-methyl-1-pentanol

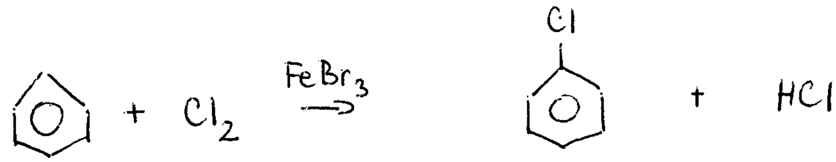
g)

$CH_3CH_2CH_2CH_2CH_2-OH + [O] \rightarrow$

(i) $CH_3CH_2CH_2CH_2-\overset{O}{\overset{\|}{C}}H$ pentanal

(ii) $CH_3CH_2CH_2CH_2\overset{O}{\overset{\|}{C}}-OH$ pentanoic acid

h)



chlorobenzene

i) $CH_3CH_2CH(Br)CH_3 + OH^- \rightarrow CH_3-CH_2-\overset{OH}{\overset{|}{C}H}-CH_3 + Br^-$

2- butanol

j) $HO-CH_2CH_2CH_2CH_3 + H\overset{O}{\overset{\|}{C}}-OH \rightarrow H\overset{O}{\overset{\|}{C}}-O-CH_2-CH_2-CH_2-CH_3 + H_2O$

butyl methanoate

k) $n\,CH_2=\underset{OH}{\underset{|}{CH}} \xrightarrow{\text{polymerization}} \cdots-CH_2-\underset{OH}{\underset{|}{CH}}-CH_2-\underset{OH}{\underset{|}{CH}}-CH_2-\underset{OH}{\underset{|}{CH}}-\cdots$

l) $n\,HO(CH_2)_7OH + n\,HO\overset{O}{\overset{\|}{C}}CH_2\overset{O}{\overset{\|}{C}}OH \xrightarrow{\text{polymerization}}$

$\cdots-O-(CH_2)_7-O-\overset{O}{\overset{\|}{C}}-CH_2-\overset{O}{\overset{\|}{C}}-O(CH_2)_7-O-\overset{O}{\overset{\|}{C}}-CH_2-\overset{O}{\overset{\|}{C}}-\cdots$

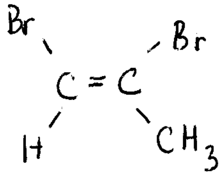
21.

a) $CH_2=CH_2 + Cl_2 \rightarrow H-\underset{H}{\underset{|}{\overset{Cl}{\overset{|}{C}}}}-\underset{H}{\underset{|}{\overset{Cl}{\overset{|}{C}}}}-H$

ethene

b) $CH_3-CH_2-CH_2-OH + [O] \rightarrow H\overset{O}{\overset{\|}{C}}CCH_2CH_3$

1- propanol

c) $HC \equiv C - CH_3 + Br_{2(l)} \longrightarrow$ 

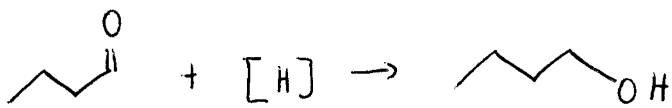
bromine

d) $CH_3 - CH(CH_3) - C(=O) - CH_3 + [H] \rightarrow CH_3 - CH(CH_3) - CH(OH) - CH_3$

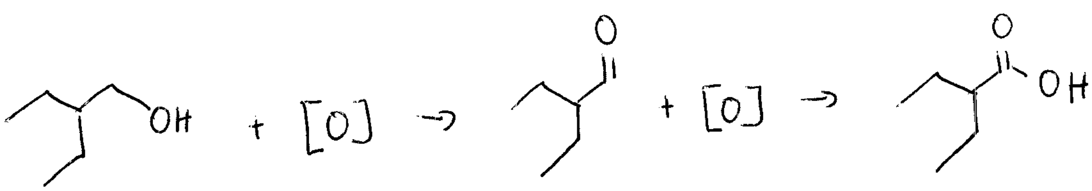
3-methyl butanone

e) $CH_3 - CH_2 - C(=O) - OH + CH_3 - CH_2 - CH_2 - CH_2 - OH \rightarrow CH_3CH_2\overset{O}{\overset{\|}{C}}O\,CH_2CH_2CH_2CH_3$

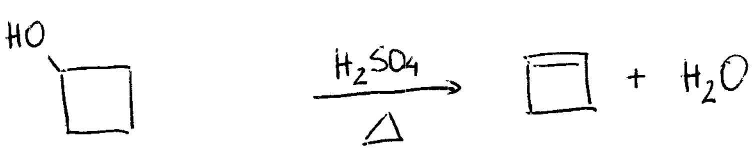
propanoic acid　　1-butanol

f) 

butanal

g) 

2-ethyl-1-butanol　　2-ethylbutanal

h) 

cyclobutanol

(i) $n\,CH_2 = CH - CH_2 - CH_3 \xrightarrow{\text{polymerization}} \ldots - CH_2 - CH(CH_2CH_3) - CH_2 - CH(CH_2CH_3) - \ldots$

1-butene

UNIT 2 - ENERGY CHANGES AND RATES OF REACTION

① If the enthalpy change for the original equation is ΔH, then the enthalpy change for the manipulated equation will be $-3 \times \Delta H$.

② a) $Li_{(s)} + \frac{1}{2} Cl_{2(g)} \rightarrow LiCl_{(s)}$

b) $C_2H_4 (g) + H_2O (g) \rightarrow C_2H_5OH (l)$

c) $NH_{3(g)} + HNO_3 (l) \rightarrow NH_4NO_3 (s)$

③ $Q = mc\Delta T$

$m = 2000g$ (2000 mL of water with $d = 1.00 g/ml$)

$c = 4.184 \ J/g°C$

$\Delta T = 39.6°C - 22.3°C$
$= 17.3°C$

$Q_{surroundings} = 2000g \times 4.184 \ J/g°C \times 17.3°C$
$= 1.45 \times 10^5 \ J$
$= 1.45 \times 10^2 \ kJ$
$= 145 \ kJ$

$\Delta H_{reaction} = Q_{system} = -Q_{surroundings} = -145 kJ$

Since 10.0 g of acetic acid was used, in terms of kJ/g the enthalpy will be $-14.5 \ kJ/g$

$M_{acetic\ acid} = 60.06 \ g/mol$

$n = \frac{10.0 g}{60.06 g/mol}$
$= 0.167 \ mol$

$\Delta H_{acetic\ acid} = \frac{-145 kJ}{0.167 \ mol}$
$= -868.26 \ kJ/mol$

(4) $CH_3Cl_{3(l)} + 3HCl_{(g)} \rightarrow CH_{4(g)} + 3Cl_2(g)$

(1) $\frac{1}{2} H_2(g) + \frac{1}{2}Cl_2(g) \rightarrow HCl(g)$ $\Delta H° = -92.3$ kJ REVERSE × 3

(2) $C(s) + 2H_2(g) \rightarrow CH_4(g)$ $\Delta H° = -74.8$ kJ/ LEAVE

(3) $C(s) + \frac{1}{2} H_2(g) + \frac{3}{2}Cl_2(g) \rightarrow CHCl_{3(l)}$ $\Delta H° = -134.5$ kJ REVERSE

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(1) $3HCl \rightarrow \cancel{\frac{3}{2} H_2(g)} + \cancel{\frac{3}{2} Cl_2(g)}$ $\Delta H° = 276.9$ kJ

(2) $\cancel{C(s)} + \cancel{2H_2}(g) \rightarrow CH_4(g)$ $\Delta H° = -74.8$ kJ

(3) $CHCl_{3(l)} \rightarrow \cancel{C(s)} + \cancel{\frac{1}{2} H_2}(g) + \cancel{\frac{3}{2} Cl_2}(g) = +134.5$ kJ

$$\Delta H = (276.9 - 74.8 + 134.5) \text{ kJ}$$
$$= 336.6 \text{ kJ}$$

(5) $(CH_2OH)_2(l) + \frac{5}{2}O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

$\Delta H° = -1178$ kJ

$$\Delta H°_{rxn} = [2\Delta H°_f(CO_2(g)) + 3\Delta H°_f(H_2O_{(l)})] - [\Delta H°_f(CH_2OH)_{2(l)} + \tfrac{5}{2}\Delta H°_f(O_{2(g)})]$$

$$\Delta H°_f((CH_2OH)_{2(l)}) = -\Delta H°_{rxn} + 2\Delta H°_f(CO_2(g)) + 3\Delta H°_f(H_2O(l)) - \tfrac{5}{2}\Delta H°_f(O_2(g))$$
$$= -(-1178 \text{ kJ/mol}) + 2(-393.5 \text{ kJ/mol}) + 3(-285.8 \text{ kJ/mol}) - \tfrac{5}{2}(0 \text{ kJ/mol})$$
$$= -466 \text{ kJ/mol}$$

(6) $C_4H_{10}(g) + 6.5\,O_2(g) \rightarrow 4CO_2(g) + 5H_2O(g)$

a) $\Delta H°_{comb.} = 5(-241.8 \text{ kJ/mol}) + 4(-393.5 \text{ kJ/mol}) - (-126 \text{ kJ/mol})$
$$= -2657 \text{ kJ/mol}$$

b) $C_2H_6(g) + 3.5O_2(g) \rightarrow 3H_2O(g) + 2CO_2(g)$

$\Delta H^\circ_{comb} = 3(-241.8\ kJ/mol) + 2(-393.5\ kJ/mol) - (-84.0\ kJ/mol)$

$= -1428.4\ kJ/mol$

c) $\therefore$ 3.0 g C_2H_6 and 7.0 g C_4H_{10}

For C_2H_6:

$\Delta H^\circ = \frac{3.0\ g}{30.08\ g/mol} \times (-1428.4\ kJ/mol)$

$= -1.4 \times 10^2\ kJ$

For C_4H_{10}:

$\Delta H = \frac{7.0\ g}{58.14\ g/mol} \times (-2657\ kJ/mol)$

$= -3.2 \times 10^2\ kJ$

Therefore, the total amount of energy released is $4.6 \times 10^2\ kJ$

(7) $4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$

a) $-\frac{\Delta[NH_3]}{\Delta t} = \frac{\Delta[NO]}{\Delta t} = -\frac{5}{4}\frac{\Delta[O_2]}{\Delta t} = \frac{3}{2}\frac{\Delta[H_2O]}{\Delta t}$

b) The concentration of ammonia decreases at a rate of $6.2 \times 10^{-2}\ mol/L$:

(8) Reactant particles must have the correct orientation, and the collision energy must be equal to or greater than the activation energy for the reaction

(9) A homogeneous catalyst is in the same phase as the reactants
A heterogeneous catalyst is a different phase than the reactants

(10) a) For exp 1 and exp 2, $[Cl_{2(g)}]$ remains constant, while $[CO_{(g)}]$ is reduced by a factor of 10. The rate is also reduced by a factor of approximately 10. Therefore, the reaction is 1st order in CO.

For exp 2 and exp 3 $[CO_{(g)}]$ remains constant, while $[Cl_{2(g)}]$ increases by a factor of 10. The rate also increases by a factor of ~ 10. Therefore, the reaction is first order in Cl_2

Thus, rate = $k[CO_{(g)}][Cl_{2(g)}]$

b) Using trial 1

$$k = \frac{\text{rate}}{[CO][Cl_2]}$$

$$= \frac{6.45 \times 10^{-30}\ \text{mol}/(L \cdot s)}{(0.500\ \text{mol}/L)(0.0500\ \text{mol}/L)}$$

$$= 2.58 \times 10^{-28}\ L/(\text{mol} \cdot s)$$

(11) a) For exp. 1 and exp. 2, $[B_{(aq)}]$ is constant, while $[A_{(aq)}]$ increases by a factor of 3. The rate increases by a factor of 9 (that is 3^2). Therefore, the reaction is second order in $[A_{(aq)}]$

For exp. 1 and exp 3, $[A_{(aq)}]$ is constant, while $[B_{(aq)}]$ increases by a factor of 2. The rate also increases by a factor of 2. Therefore, the reaction is first order in $[B_{(aq)}]$

rate = $k[A_{(aq)}]^2[B_{(aq)}]$

b) The reaction is third order overall

c) Using trial 1

$$k = \frac{\text{rate}}{[A]^2[B]}$$

$$= \frac{5.00 \text{ mol}/(L \cdot s)}{(0.200 \text{ mol}/L)^2(0.0200 \text{ mol}/L)}$$

$$= 625 \text{ L}^2/\text{mol}^2 s$$

12. rate = $k[C][D]^2$

When rate = $0.10 \text{ mol}/L \cdot s$, $[C] = 1.0 \text{ mol}/L$ and $[D] = 0.20 \text{ mol}/L$

$$k = \frac{\text{rate}}{[C][D]^2}$$

$$= \frac{0.10 \text{ mol}/Ls}{1.0 \text{ mol}/L \times (0.20 \text{ mol}/L)^2}$$

$$= 2.5 \text{ L}^2/\text{mol}^2 s$$

a) rate $= 2.5 \text{ L}^2/(\text{mol}^2 s) \times 2.0 \text{ mol}/L \times (0.20 \text{mol}/L)^2$

$= 0.20 \text{ mol}/Ls$

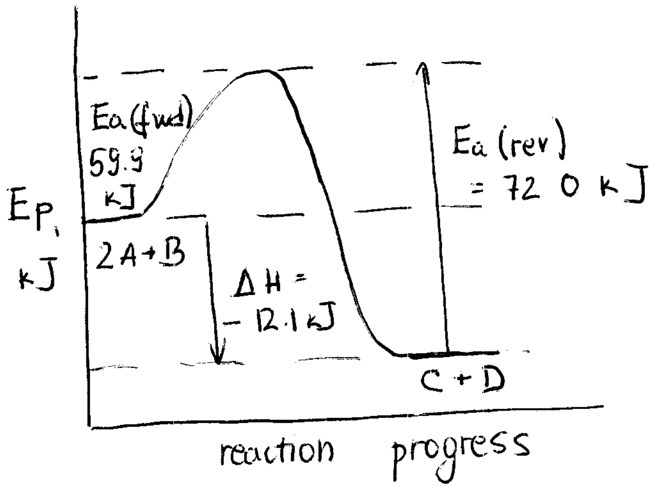
b) rate $= 2.5 \text{ L}^2/(\text{mol}^2 s) \times 2.0 \text{ mol}/L \times (0.40 \text{ mol}/L)^2$

$= 0.80 \text{ mol}/L \cdot s$

13.

a) $\Delta H = 59.9 \text{ kJ}/\text{mol} - 72.0 \text{ kJ}/\text{mol} = -12.1 \text{ kJ}/\text{mol}$

b)



(14) a) Assume a bimolecular reaction in step 1 being slow and each of the other steps are fast

rate = $k[A][B_2]$

b) Assuming that the intermediate AB_2 forms in a fast step the rate law is

rate = $k[AB_2][C]$

c) /

(15) a) Activation energy, E_a, is the minimum energy that a collision must have for a reaction to take place

b) Temperature represents the average kinetic energy of particles in a substance. At ↑T particles have ↑ average kinetic E. More collisions therefore have energy equal to or greater than the activation energy. Thus, reaction rate usually increases as T↑.

c) A catalyst provides an alternative mechanism for a reaction. The steps in the catalyst mechanism will likely have activation energies that are smaller than the activation energies in the original mechanism.