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OpenCourseWare (2023)

CHEMISTRY II

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SOLUTIONS OF EVALUATION TEST 2

1. *(3 points)* Indicate which of the following statements are TRUE or FALSE, and correct the False one. (Correct answers mark as **+0.25**).

A	Regarding the following Redox pairs, Pb^{2+} is the strongest reducing agent and I_2 is the strongest oxidizing agent. Data: $E^0(MnO_4^-/Mn^{2+})$ = 1.51 v; $E^0(I_2/I^-)$ = 0.54 V; $E^0(Pb^{2+}/Pb)$ = –0.13 V
FALSE, Pb^{2+} is the strongest reducing agent but MnO_4^- is the strongest oxidizing agent.	

B	In a concentration cell, when the concentrations of the electrodes are the same the E^0_{cell} = 0 V.
TRUE	

C	Fuel cells are electrical devices which convert chemical energy directly to electrical energy and water.
FALSE, it is obtained electrical energy, water, and heat.	

D	Specimens having rough surfaces display a greater resistance to pitting corrosion.
FALSE, A greater resistance to pitting corrosion is reached in specimens having polished surfaces.	

E	Cis alkenes are less stable than their trans isomers because of steric strain between the two larger substituents on the same side of the double bond.
TRUE	

F	A hydroxyl group deactivates the reactivity of an aromatic ring and orients the substitution on meta.
FALSE, a hydroxyl group is an activating group and directs substitution toward the ortho and para positions.	

G	The Williamson ether synthesis consists of the reaction of an alcohol with a primary, rather than secondary, halide.
FALSE, the reaction is better with a primary halide, but with an alcoxide, not with an alcohol.	

H	Phenols with an electron-withdrawing substituent, such as a nitro group, are more acidic.
TRUE	

I	Carboxylic acids can be obtained through Grignard reaction from the reaction between a Grignard reagent and an alcohol
FALSE, they can be obtained from the reaction between a Grignard reagent and CO_2, followed by protonation.	

J	In a competitive inhibition, the inhibitor can only bind to free enzyme and therefore, inhibition may be reduced by increasing substrate concentration.
TRUE	

K	Triacylglycerols are lipids composed of a glycerol molecule and three fatty acyl residues joined by a glycosidic bond.
FALSE, They are joined to glycerol by an ester linkage at the terminal carboxyl group of the fatty acyl residues.	

L	In a DNA molecule, each of the bases on one strand forms covalent bonds with a base of the opposite strand.
FALSE, Each of the bases on one strand forms hydrogen bonds with a base of the opposite strand.	

2. *(1.5 points)* Consider the electrolysis of an aqueous solution of $CuBr_2$.

a) *(0.75 p)* Write the half-reactions and indicate the products formed at the anode and cathode.

b) *(0.75 p)* What volume of bromine gas at 25 °C and 1.00 atm will be produced at the anode by supplying 0.5 A for 30 min?

Data: $E^0(Cu^{2+}/Cu)$ = + 0.34 V; $E^0(Br_2/Br^-)$ = + 1.07 V; E^0 (O_2/H_2O, H^+) = + 1.23 V; E^0 (H_2O/H_2, OH^-) = – 0.83 V; M (Cu) = 63.55 g mol^{-1} and M (Br) = 80 g mol^{-1}; F = 96500 C mol^{-1}.

SOLUTION

a)

Oxidation (Anode) $2\ Br^- \rightarrow Br_2 + 2\ e^-$ $\quad E^0 = -1.07\ V$

$2\ H_2O \rightarrow O_2 + 4\ e^- + 4\ H^+$ $\quad E^0 = -1.23\ V$

Reduction (Cathode) $Cu^{2+} + 2\ e^- \rightarrow Cu$ $\quad E^0 = +0.34\ V$

$H_2O + 2\ e^- \rightarrow H_2 + 2\ OH^-$ $\quad E^0 = -0.83\ V$

Overall Reaction $2\ Br^- + Cu^{2+} \rightarrow Br_2 + Cu$ $\quad E^0 = -0.73\ V$

Br_2 is produced at the anode and Cu at the cathode.

b)

Faraday's Law

$n(Cu) = I \times t(Cu) / n \times F$

$n(Cu) = 0.5 \times 30 \times 60 / 2 \times 96500$

$n(Cu) = 4.66 \times 10^{-3}\ mol$

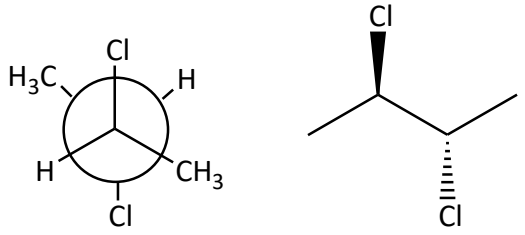
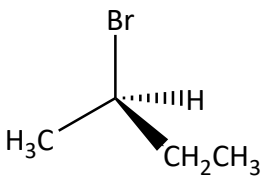
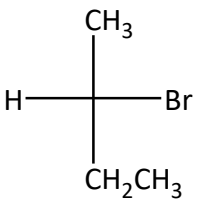
$n(Cu) = n(Br_2) = 4.66 \times 10^{-3}\ mol$

$V_{Br2} = n_{Br} \times R \times T / P = 0.11\ L$

3. *(2 points)* Consider de following pairs of compounds A and B.

a) *(0.8 p)* Which of the following terms best describe the pair of compounds shown: enantiomers, diastereomers, or the same compound?

b) *(0.8 p)* Find the R/S configuration of the chiral carbons for all of them.

	Compounds A		Compounds B	
				
a)				
b)				

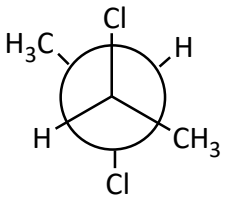
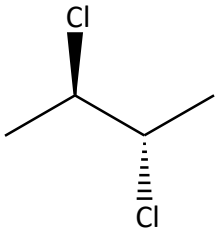
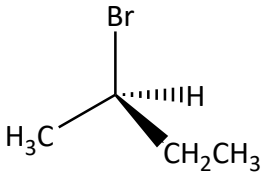
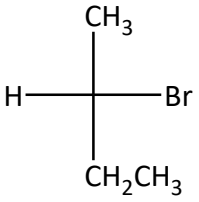
c) *(0.4 p)* Alkyl halogenides experience nucleophilic substitution reactions (SN) which are used in the preparation of alcohols from alkyl bromides as depicted in the following scheme:

$$R\text{-}Br + OH^- \rightarrow R\text{-}OH + Br^-$$

There are two main reaction mechanisms, S_N1 and S_N2, which differ in the kinetics and stereochemistry. It has been found that the rate of disappearance of BrE under almost neutral conditions is given by $v_A = k_A[BrE][OH^-]$ while the corresponding rate equation for 2BrP is $v_B = k_B[2BrP]$. Which is the difference in reaction mechanism for both molecules that may explain the difference in the kinetics?

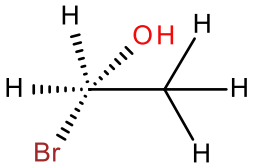
SOLUTION

a) and b)

	Compounds A		Compounds B	
				
a)	**Same Compound**		**Enantiomers**	
b)	***RS***	***RS***	***R***	***S***

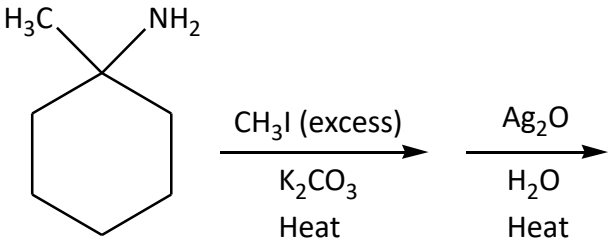
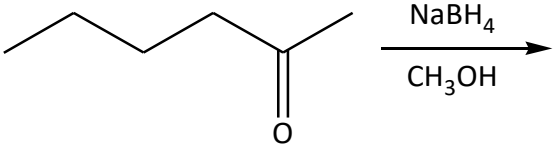
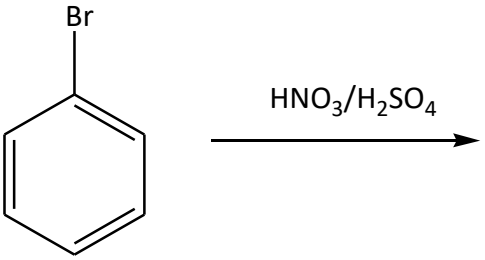
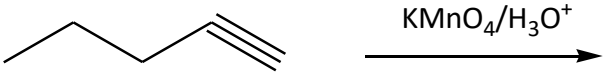
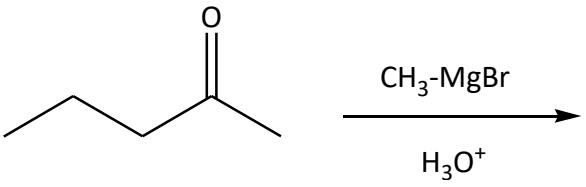
c)

BrE follows a S_N2 reaction while 2BrP follows a S_N1. This means that the intermediate in BrE is a complex formed by the OH- attacking the molecule by the opposite side where bromine is located, as depicted in the following scheme:

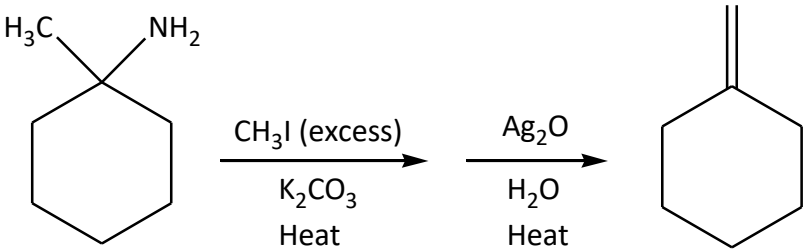
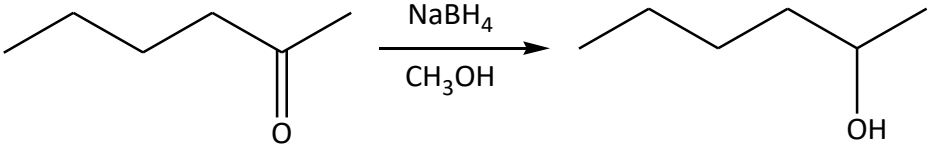


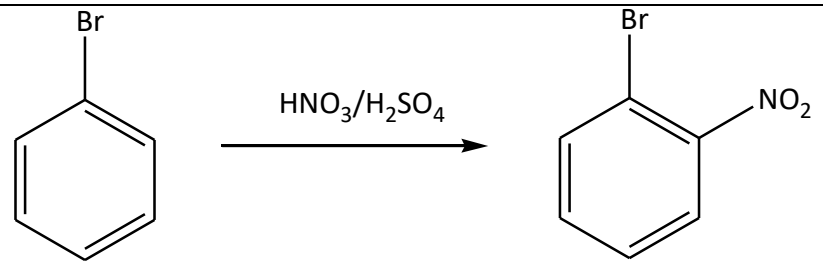
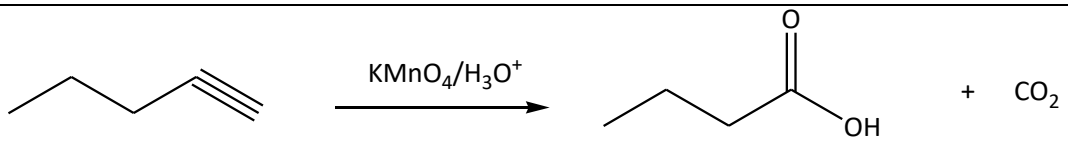
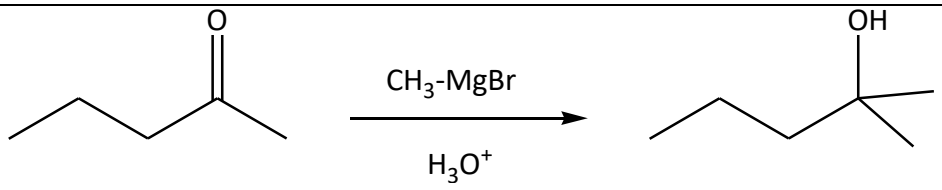
In the case of 2BrP, reaction occurs via two steps, the slowest being the formation of a stable tertiary carbocation. Consequently, the reaction appears to be unimolecular.

4. *(2.5 points)* Which product would you expect to result from the following reactions?

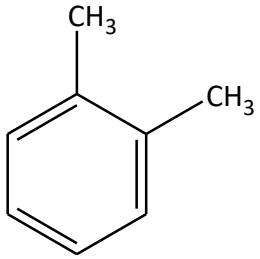
a)	
b)	
c)	
d)	
e)	

SOLUTION

a)	
b)	

c)	
d)	
e)	

5. *(1 point)* (a) *(0.5 p)* The organic compound $CH_3C(CH_3)(OH)CH_2CH_3$ (2-methylbutan-2-ol) shows 4 different peaks in the ^1H NMR spectra. Predict the splitting pattern. (b) *(0.5 p)* How many different types of carbon would be present in the following molecule?



SOLUTION

a) **The predicted splitting pattern will be a triplet corresponding to CH_3 bonded to CH_2, a quartet corresponding to the CH_2 bonded to CH_3, a singlet corresponding to 2 CH_3, and a singlet corresponding to the OH.**

b) **There will be four different peaks in the ^{13}C spectrum:**

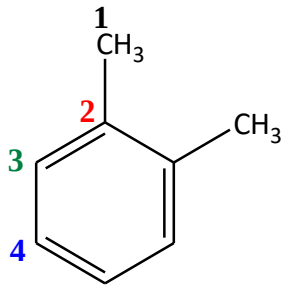


IMAGE CREDITS

- Images were made by authors.