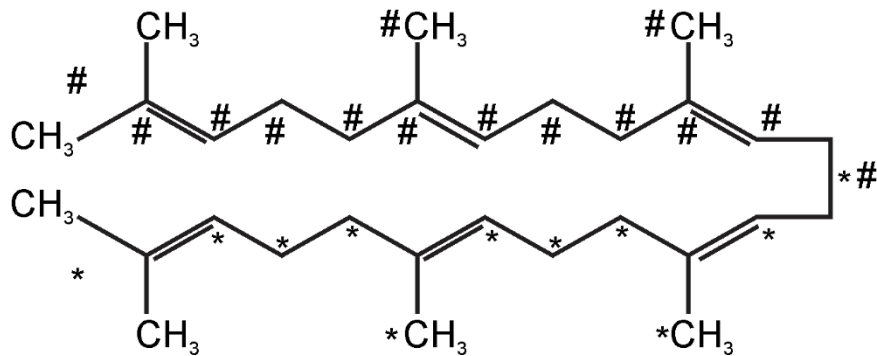


6XJJHVWHG \$QVZHUV

9&(&KHPLVWU\ 7U<HDDU([DP 8QLWV

6(&7,21 \$ ± 0XOWLSOH &KRLFH \$QVZHUV

4 & 7KH VHPL VWUXFWXUDO IRUPXOD RI VTXDOHQH LV
&+ & &+& &+ &+&+& &+ &+&+
|
&+ & &+& &+ &+&+& &+ &+&+
7KH DUH QR & DWRXUV ERQHGW DWRFFKURXS V KH
FDUERQV
6TXDOHQH PROHFXOHVDWHPISKDPHMGLEDWKH VNHO



6TXDOHQH PROHFXOHVDWHPISKDPHMGLEDWKH VNHO
VNHOHWDO VWUXFWXUH
6TXDOHQH PROHFXOHVDWHPISKDPHMGLEDWKH VNHO
VNHOHWDO VWUXFWXUH

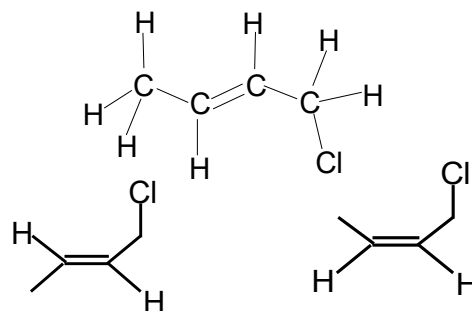
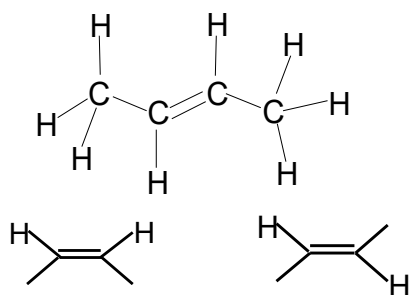
4 % n & + 2 J J PRO
PRO
(QHUJ\ UHOHDVHG IURP FRPEXVWLRO-RPPOPSKRU
N-
'7 N- N- .
. & WHPSHUDWXUH FKQDQG .DUH WKH V
,QLWLDO WHPSHUDWXUH ±
&

4 & 7KH LQGXFHG ILWDFRGLYDWR\ UHQIRUPZWRXVXUWLWRD
D VXEVWUDWH UHDFWLYW VEDWVFKWKKHHQRPH WR
VKDSH FRPSOHPHQWDU\ WWRVDDWRZI WKKH LQVWDE
IRU UHDFWLRQ WR RFFXU

4

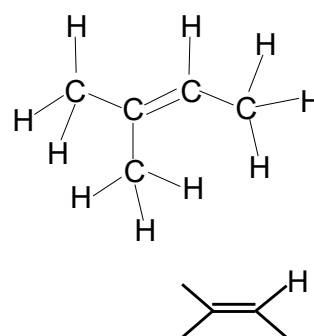
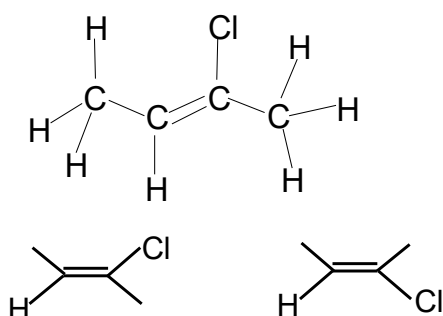
% XW HQH

FKORUREXW HQH



FKORUREXW HQH

PHWK\OEXW HQH



4 \$ (QHUJ\ UHOHDVHG GXULQ & FRPEXVW & RQ - J

n K\GURFDUERQ EXUQW N- N- PRO
M K\GURFDUERQ J PRO
5HODWLYH PROHFXODU PDVV

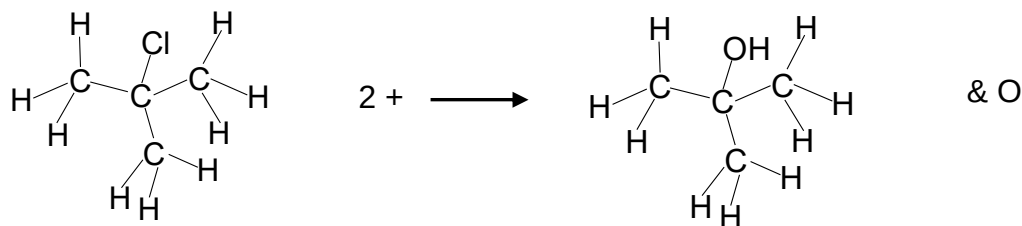
4 & 7KH NH\ SLHFH RIWLQH RGLDWHFWRU QNRD QIRYD FHQW RI
,Q DOO HOHFWURQV LFDOHFWURQV DOO VLVWV KHDQV RQ
FHOOVQH LV DWLONHFWURGH
,Q DOO FHOOV VWWH RQRGLGFWWRQV FIKWHT UQGXKH
< V KDOI FHOO LV < V
7KH KDOI HTQ BWLWRY BWH QKFWUTR GHH LV < V

4 \$ 7KH DPLQR DFLQWRVEPRW WHORQH ZULWRWWHRJQ HRDWH
QLWURJHQ DWRLR Q9 RV XDPQLR DSHFWXUHV I
Chemistry Data Book (Table 17) V X J DHUWQLQH
3URSRUWLQRQm E1 M DPLQR DELG @ î
\$UJLQ±QH î
\$VSDUDJLQH ± î
+LVWLGLQH ± î
/VLQH ± î

4 ' \$FFRUGLQJ WR HOHFWURFKHPLFDO VHULHV WR
Eq \$J\$J 9
Eq 3E3E 9
E \$J\$J 3E ± 9
\$FFRUGLQJ WR WKHQHFWLRQ ZH FDQ GHGXFH
E \$J\$J < 9
6LQFH \$J\$J 9Eq WKHQXPXVW EH HLWKHU
ZKLFK ZRXOG SODFH DOWRQ WKH WDRGH SRWHQWLDO
± 9
Eq < < Eq \$J\$J E±FHO ±
9
6R H[SDQG WKH HOHFWURFKHPLFDO VHULHV WR
Eq \$J\$J 9
Eq 3E3E 9
Eq < < 9
Eq 3E DT 3E VDT < V ±
9
E 7ODT 7O VDT < V ± 9
9
Eq 7O7O LV HLWKHU PRUH RU L HOHVVRWDO
7KH ODWWHU LV XQOLNB\ WQFHWRZMLOG SODF
6R 7O7O
(OHFWURFKHPLFDO VHULHV EHFRPHV
Eq \$J\$J 9
Eq 3E3E 9
Eq 7O7O 9
Eq < < 9
6WURQJHVW UHGXFWDQW LV <

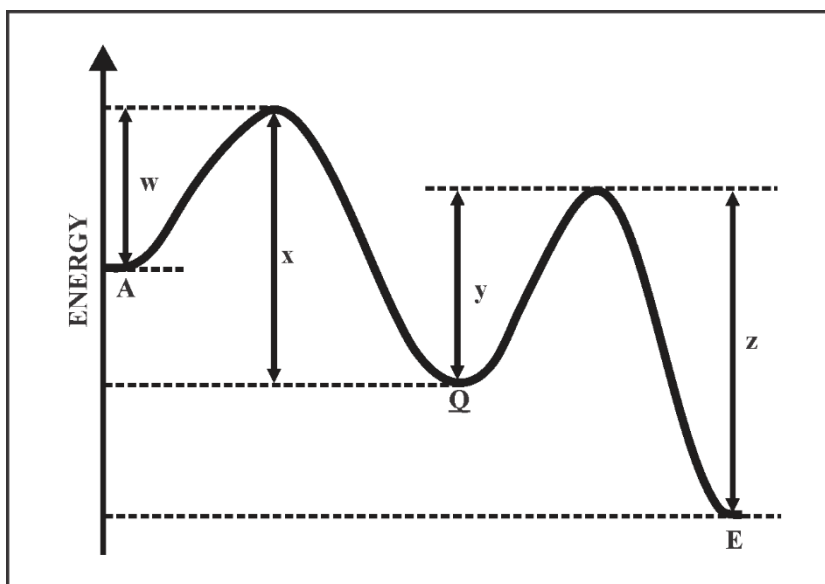
4 % c HWKDQRO LQXGHXWH P P 9
c HWKDQRO LQXGHXWH P P 9
P 9
J LQ PRO
m &+&+2+ LQ P/ J J PRO
PRO
c &+&+2+ PRO /

4 \$,Q 1D2+ DT FKORURPHWK\OSURSDUQHSZQOORH FR



\$V WKH@>2HFUHDVHV GXHSWFZVOKGHFDFWLRQ WKH

4 % &RQVLGHU WKH WKZRFRVQYJHWLRQ RI \$ WR (

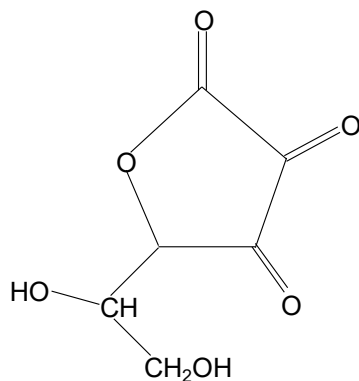


(QHUI\ FKDQJH \$
(QHUI\ FKDQJH ±4\
7RWDO HQHUJ\ (FKDQJH \$] \
_____ ± Z ± \

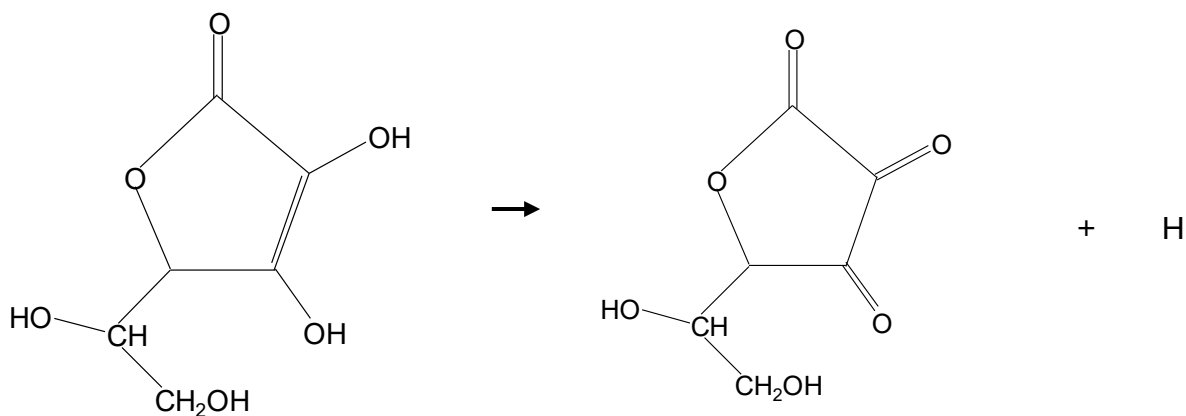
/H DUQLQJ 0WJHUVWVG \$QVZHUV 9& (&KHPLOVQDLWV <H DU

4 % 7KH VWUXFWXUH RI GLYKOLIC ACID Table 17.0 of the CRC Chemistry Data Book

7KH ORVV RI KIGUWLRQ WR WKH RQHG DFDWLYH LW KDFW C
LRQV ZLOO EH UHOHDVHG GXULQJ WKH DMLRQW WRQH
FKDUJH RQ WKH ZLOO EH EDODQF WKH RYOHUOORFKD
DVFRUELF DFLG UHPDLQV]HUR
7KH RQO\ VWUXFWXUH FRQVLVWHQW ZLWK WKH KD

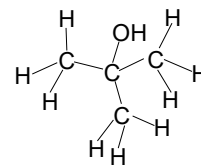
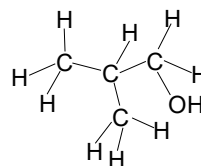
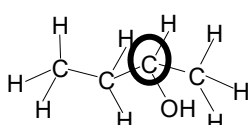
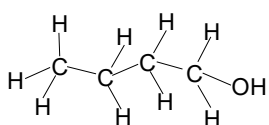


7KH KDOI HTXDWLRQ IRU WKH R[LGDWLRQ LV



RU +2 o &+ 2 + H

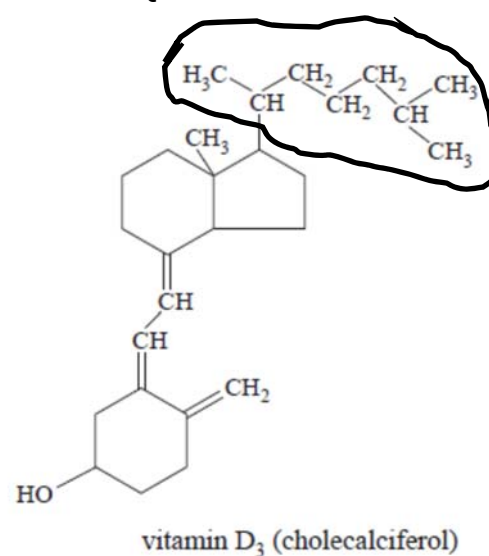
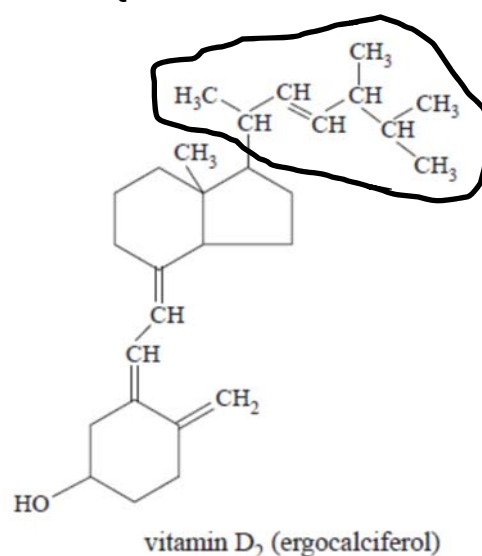
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UHVXOWLQJ KILURDORQH QWUH
2QO\ EXWDQ RQKDWHD LF KILUD EDUE RQ IHRUHQHG DW
JURXSV RI DWRPV



/HDUQLQJ OXWJHUVHG \$QVZHUV 9& (&KILURDORQH QWUH <H DU

4 \$ (TXDWLRQ IRU WLWUDWLRQ UHDFWLRQ
 2+ &22+ D& 1D2&+D2+ &221D D2 O +
 Q 1D2+ XVHG x x PRO /
 x PRO
 P ODFWLF x DFLG PRO J PRO
 J
 P PLON x PJ/ P/
 J
 ODFWLF DFLG
 P P

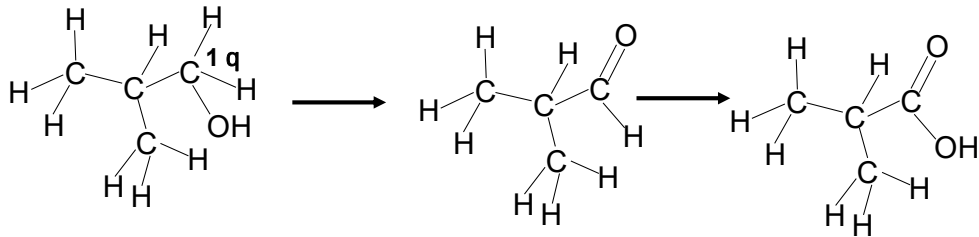
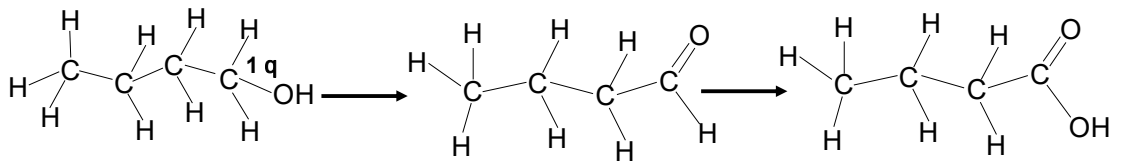
4 ' 7KH VWUXFWXUH RI BIYLLWDPHLOQ K'RZQ LQ VEEOH LQ
 Chemistry Data Book 7KH GLIIHUHQFH EHWUXHUV ZH HQWLQWWKH K\G
 FKDLQV DWWDFKHG WR WKH ULQJ VWUXFWXUH



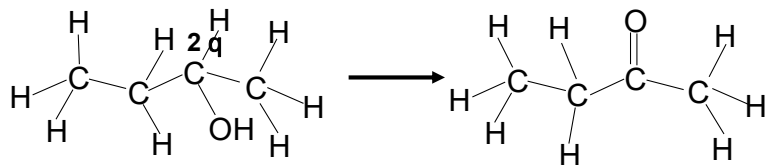
7KH IRUPXODH RI WKH UHVSODFHV VLGH FKDLQV
 7KH H[WUD FDUERQ DWRQV LV QDWLWDLVQLQWHUPROHF
 IRUFH DWWUDFWLRQ ZLWV FHOVWLQK EWHRSHUDWXUH

4 % 7KH FKHPLFDO VKLIW RI D + RU & DWRV VLSH DWPXPH
 LV GHWHUPLQH E\ WKH UHODWLYH HVWGHH[SJWLK HQ FV
 E\ WKH DWRPV ([SRVXUH WR WKHVRDHIQSWQF HLIHOFV
 HOHFWURQV VXUURWQGLQVQKIG DWWDFH H FKL VWKLH
 UHGXFHG E\ WKH SOHFWURQ RJ DPHOHF DWR PZK ILQWK
 PHDQV WKH QXFODLVDWRQ JSRVPHHQWQV OLHOGK H F
 HQHUJ\ JDS EHWZHHQ WKH WZR QXFOGHRSWQV VV
 FKHPLFDO VKLIW

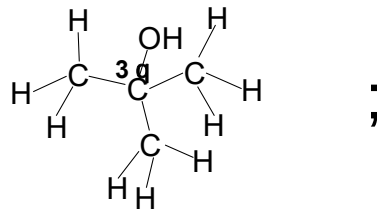
4 ' ,Q WKH SUHVHQFH RI DFLGLLHG GLFKURPDWH
SULPDU\ DUFKROVPHV\OSURSDQH ROLGLVHG WH
DOGHKDOH\VFUER\OLF DFLGV



VHFRQGDU\SDUFROR[LGLVHG WR NHWRQH



WHUWLDURHWRKURSDQHRO R[GLVHG



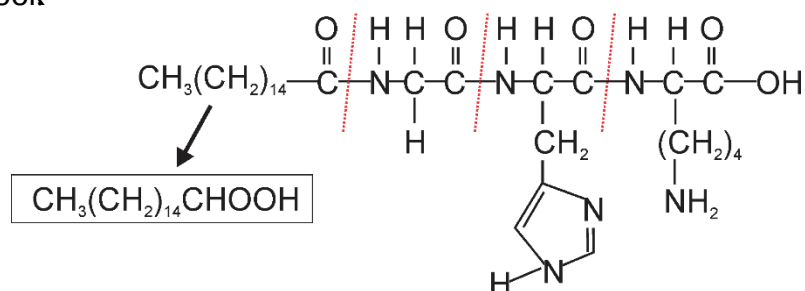
+HQFH PHWK\OSURSDQ RO ZLOOHGXLUH WKH
GLFKURPDWH

4 % BBBB+BBBo&2+ q BBBB+
BBBBQ+2o &+ q BBBB+
BBBBQ+2o &+ q Q+ 2
7RWDO QXPHRURUJWR Q Q
1XPEHU RI + DWRPV UHTXLUHG RQ OHIW Q
1XPEHUPROMFXOHV UHTXLUHG RQ O
2YHUDDO HTXDWLRQ
Q + Q&2o &+ q Q+ 2

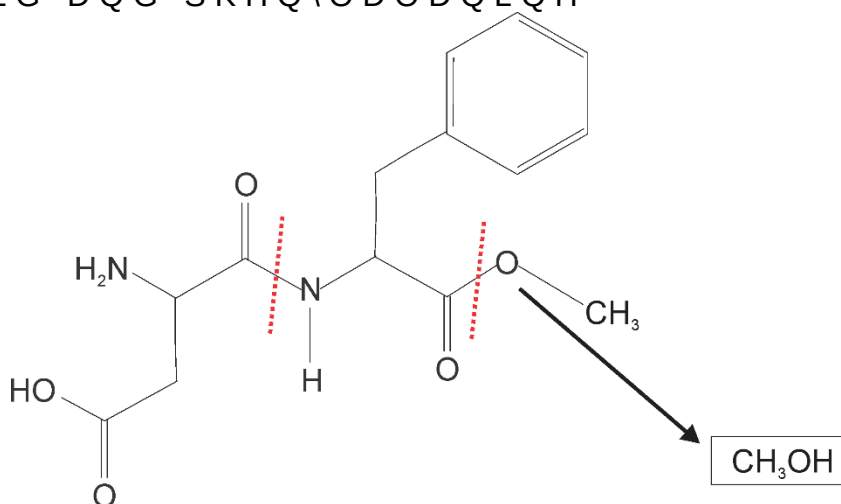
/H D U Q L Q J 0 6 X J H U H L D W H G \$ Q V Z H U V 9 & (& K U H P L O V 8 Q L P W V < H D U

4

& +\G URO\WLOPRWR\ZLOO SBOFDWHF BFLG 2 2++D QK UHH
DPLQR BFLGVLQH KLV WidenificQ/HmDQb 1On VLEQChemistry
Data Book



+ \G URO\WLSVDMZDPO PHOKDVHPO BQZR DPLQR DVFSDN
DFLG DQG SKHQ\ODODQLQH



8QGHU DSSURSSDDWHWLFQDFLGLRQQ UHDFW FZHWK\O
SDOPLVEDWBLHVOHO

&+ &22+ & &2+ & &+ &22&+ +2

,Q DONDOLSDHOPRQGLVLRQV DQG \$VSDUWDPH ZLOO D
ERWK KDYH D VLQSHWKDWERDQ BHHXMS QPWRBQDGWVIG
WKHLU DPLQR DFLG VLGH FKDLQV

4

7KH HTXDWLRQ HRRURWKXIVMLRSOR RWP HWKDQH LV
&+ J 2o &2J 2+ J

6LQFH PROF&V ZLWKWRP RLOY B J PROG&2PRO WKHQ
VLQFH DOO YROXPHV DUH PHDVXUN&UDWWWK KHYRDXHP
UHDFWLRQ LV WOH VDWHLFDVQWWKHP RITXDWLRQ

6R PU&DFWV ZLWWR JLP/H2 DR/G&2 P/ +

&2DQG D&H DOO JUHHQKRXVH JDVHV

,QLWLDO YROXPHVJ&HHQKRXVH JDVHV

P/

)LQDO YROXPH JUH&QKRXVH JDVHV

P/

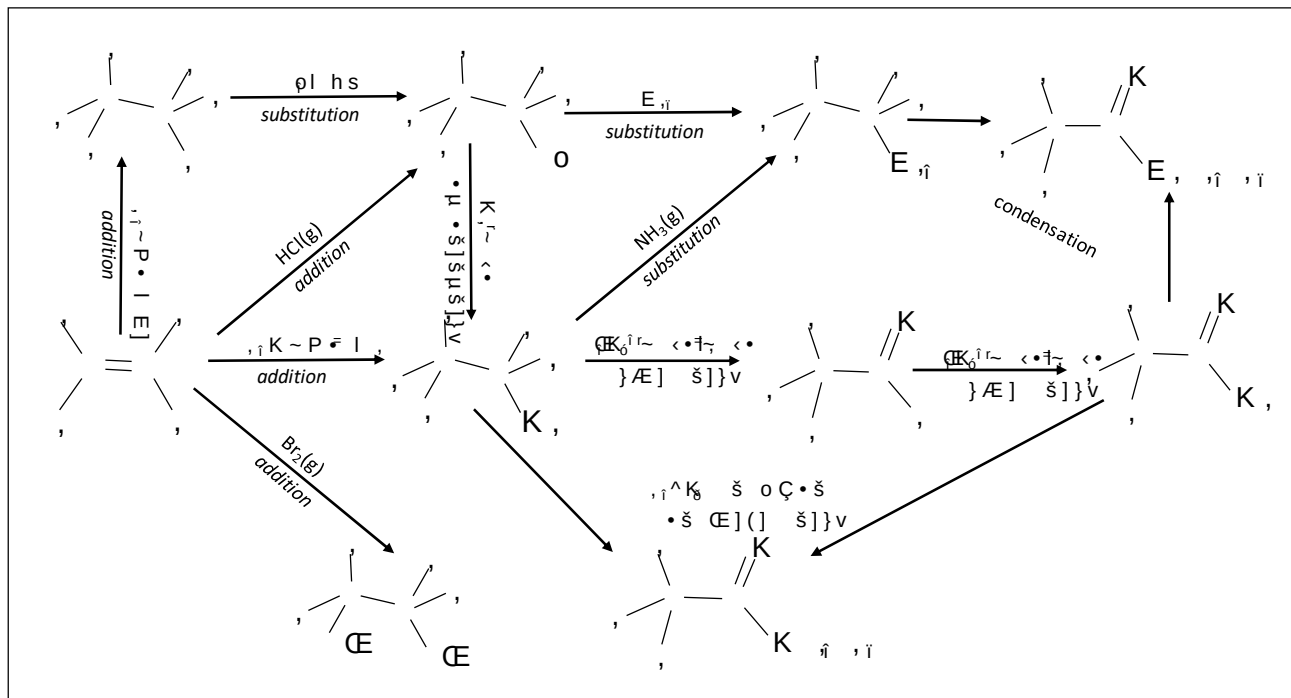
P/

PRO

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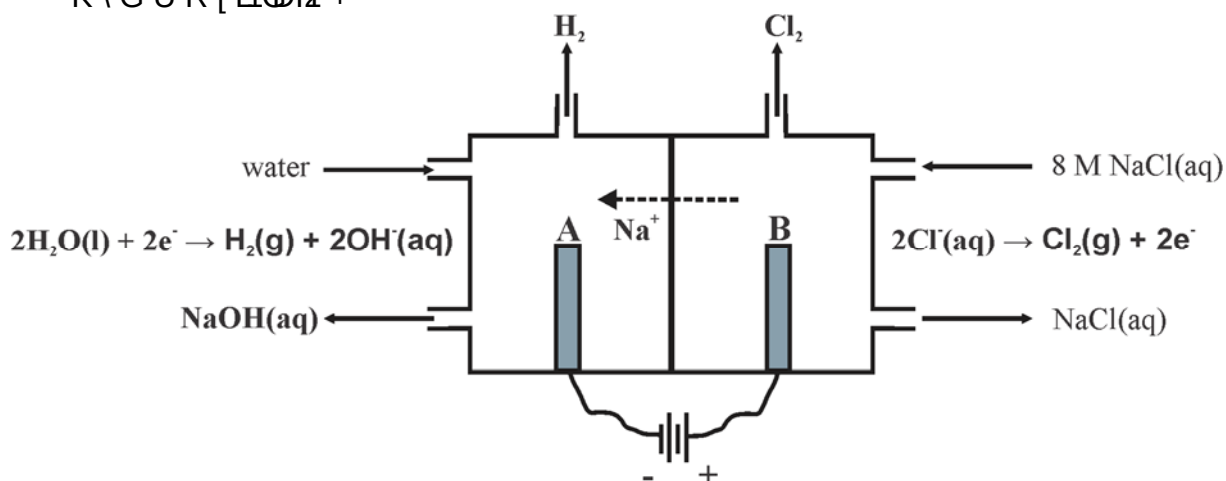
4 & \$FFRUGLQJ WR VOE Chemistry Data Book HWKH KHDWV RI FRPE
 FRPSRXQGV LQ 0 DUH
 0HWKDQRO N- J
 2FWDQH N- J
 0 LV PHWKDQRO DQG RFWDQH
 V &+2+ LQ / 0 î /
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 V &+ LQ / 0 î /
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 Jî
 7RWDO HQHUJ\ FRQWDL-QHG î Jî J N- J
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 î N-

4 % +%U LV QRW SDUW RQWKDSDWKLEQDUEHEDLOHG



4 & Q It
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 Q $\hat{I}$ $\hat{I}$ $\hat{I}$
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 n H Q F $\hat{I}$
PRO
2[LGDWLRQ KDO/ILHTXDWLRQ /L
 n /L PRO
 m /L $\hat{I}$ PROJ PRO
J

4 % 6SHFLHV SUHVHQW WRQRQRD TXRGLXP FRKBDLGDUH
\$FFRUGLQJ WR WKH SRZHUAWSQBQRMDWLRIQ
7KH SURGXFWV RI WKH HOHFWUERGYPWKIRIHCH&FOWDT
VHULHV
 $Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$ 1.36 V
 $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$ 1.23 V
 $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$ -0.83 V
 $Na^+(aq) + e^- \rightarrow Na(s)$ -2.71 V
2 O ZLOO EH UHGRGHG ZDMFVKM WDNRGHHJLQWLOHFW
\$W WKH DQRGH $\pm$ WKH SRVLWL&O OCHFDVQGDTH ZLOO
EH R[LGLVHG 8QGHU VWDOGDGEHF SQURBOEFLOV DDOO
EH SURGXFHG 7KDWLWYHOHPW O DURLQWHXOVLUQZQOKVXQB
&ODT
+DOI HTXDWLRQO\RLU WKH HOHEWDT DUH
HOHFWDRG&O &CH
HOHFWRGRGHJ H
6R WKH FRPSRXQVKH[WDOFVHVGUWHBOFRQVW
K\GUR[LCH+



6(&7,21 % ± 6KRUW \$QVZHU \$QVZHUV

4XHVWLRQ PDUNV

D 0DVV RI VSLULW RIDEALUQHMKHIZBWHM E PDQYURDMSHU
DOO IRXUODOFRKROV

7HPSHUDWXUH FKDQJH RI WKH ZDWHU LQ WKH FDQ
E 0ROHFXODU PDVV PRODU PDVV RI WKH DOFRKROV
7KH LQGHSHQGHHQWQYHDYDD EOGI G WMLKQWDQHG LQKHH VWL
KDYH GLIIHUHQW BDYHDGVHWHUHQW HPRXODU VLJHV

F 2QHORI
9ROXPH PDVV RI ZDWHU EHLQJ KHDWHG
'LVWDQFH EHWZHHQ EXUQHU DQG ZDWHU FRQWDLQHU
/HQJWK RI ZLFN H[WHQGHHG IURP EXUQHU
\$PRXQW RI VWLUULQJ RI ZDWHU
&RQWUROOHG YDUZKLEFCHDUDHUNHISRVWUEROQVWBD QHQ DXU
RXWFRPH RI WKH WHHQDWKLRQMSESGMMQZI YDPEXEOHLREQH
LQGHSHQGHHQWHYFDOHDEIQH ± ERG SURGXFHG

G (QHUJ\ DEVRUEHG EVZDWHU & - J

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n & + & + & + 2 + J J PRO

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0RODU KHDW RI FRPEXVWIRPRO ↑

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H 'XULQJ WKH FRPEXVWLWIRPRO OWKQHDQF RUKHOHD WKH GH S
QXPEHU RI & & DQG & + ERQGV ZKLFK DUH FEU&NHDQDQ
ERQGV IRTPHQHUJ\ UHOHDWKH GHIIOHUHQFH EHWZHHQ V
ZKHQ & 2 DQG 2 + ERQGV DUH IRUPHG DQG & WKHQ & U
ERQGV VKHDUJHU WKH DOFRKRO PROHFXOHV G&H JUHD
ERQGV EURNHQ DQG & 2 DQG 2 + ERQGV RQWPHG HDQHU
UHOHDVHG LQ WKHQHPRPEWVWLWIRPRO KRI DOFRKRO

I 7KHHTXLSPHQW VHW XS GRWKHQWDPQVLEHGR EHQRPBXV
WKH DOFRKRO WHRQWKHWZBWFHDQFROBWGIEHQKHQZDWHU
HQHUJ\ UHOHDVHG GXULQJ FRPEXVWLWLRQ
3RVVLEOH PRGLLFDWLWLRQV FRXOG EH
r SXWWLQJ D OLG RQWKHGFRQWBDQHDORVV IURP WKH
r DGGLQJ D SURWHFWLYH VKLGHQFH DQHDQGRWKHVERXWQ

J HIILFLHQF\ >HBDWOREKDBWENGWLRQI FRPEXVWLRQH@

↑

①

MCR Chemistry Data Book

K 7KH FDORULPHWHUJLQBERVSKHDBWHFMDQHEURDO WKH
WKHUPRPHWHU 7GLVRLV LQWKFHRSXQWHQVGD O WHFK

4XHVWLRQ PDUNV

D + J J $\rightleftharpoons$ +, ①

E 7KFRQFHQWUDWLRQ, MFRUH DVH DQG WKH FRQFHQWUDWLRQ
LV QR FKDQJH DIWHWKH GDFLQJ DOWKHH WKRVH WIKVWH IRUZ
GHFUHDVHV ZLWK WLPH VLQFH WKH FDOGDWLRQ DEQLORRX
SURGXFHG EHRPH LQFURKHVLIQJ FRQWUDWDEULWZHDWLQ
UHDFWDQW FROGLDQV QVHDGHFKUHH DVLQWKHRZH, YHUV LQ
UDWH RI WKH UHYLEBVDUHLQFWLQWDDWKHGH BBRQVGLV U
ZKHQ WKH UDWHV RI WKH IRUZDUG DQG WKHYHUHV QIR
FKDQJH LQ DPRXQW RI UHDFWDQW FRHUGSHURXGLOFWE DLV

F K >+, @>@ ①
 $n +, V \quad \hat{n} + V \hat{n} \quad , \quad V$
 $n +, \quad n^+ \hat{n} \quad , \quad \hat{}$
 $\hat{}$

①

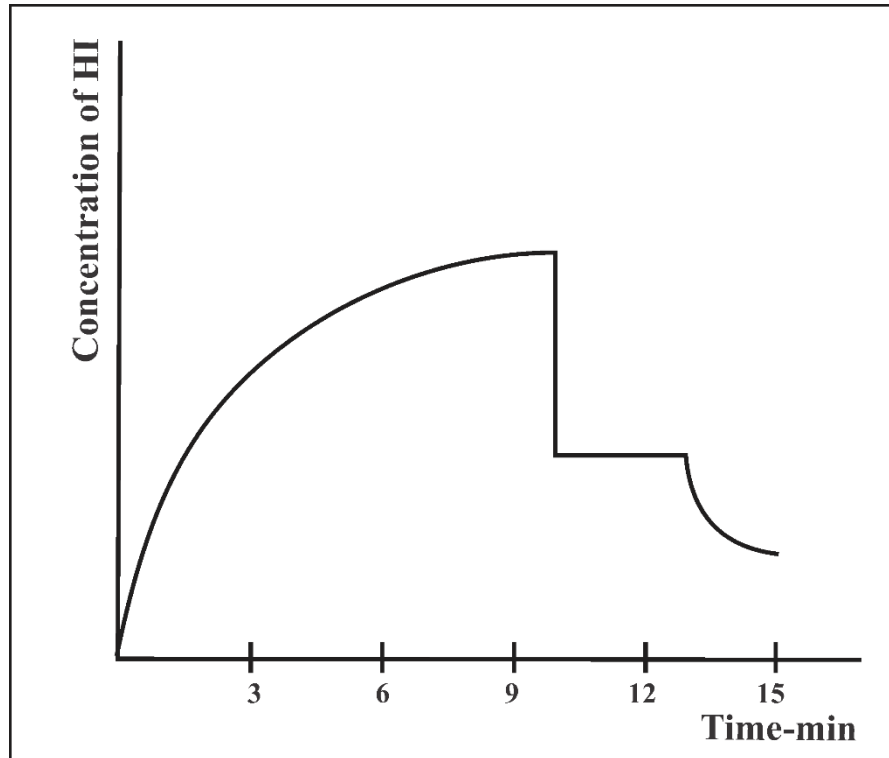
There are the same number of particles on both sides of the equilibrium, so

L WKH DFWXDO YROXPH LRIQVWHQFHQWLRQ 9FBDFXWDLV
RXW

LL. GRHV QRW KDYH DQ\ XQLWV

G 7KHROXPH LQFUHDVH ZRXOG FDXVH DOGHFBQBNQWUKH
SUHVVRUZHYYHU EHFDXWHPWKXUPEHDUHHVSKHBWKFOHGHV
HTXLOLEULXP LW FDQQRW VKLIW WRHQFHSWXQVWHRIIRU
UHDFWDQWV DQG SURGXFWV SUHVHQW GR QRW FKDQJ
7KGHFUHDVH LQ ZRXPGLQFWXHHWKH V\VIWHRXWRQFJRWSKH
H[RWKHUPLF \$HFRUGLQQ WR VRIHQGLVQD FKHQWHPHSHWKD
ZDV WKYHUHVH ①HDFWLRQ

H



7K+ , @ VWDUWV DW JHUR DQG LQFUHDVH LQ WKH PDUN
PDUN UDWKH RI LQFUHDVH DQG LQFUHDVH LQ WKH PDUN
PLQXWHV
\$W WKH PLQXWHV WKH PDUNV WKH PDUNV WKH PDUNV
OHHYHO XS WR WKH PLQXWH PDUN
%HWZHLQ PLQXWHV DQG PLQXWHV WKH > +, @ LQ FUHDVH
E\ WKH WHPSHUDWXUH GHFUHDVH

4XHVWLRQ PDUNV
D & V J2 & 2 J & V J2 & 2
E ([SRVXUH WR & 2 FDQ DIIHFW WKH FRPSDQWLWV RI WKH
ERG\
2[\JHQ FRPELQHV ZLWK KDHPRJOURSLQV HQWUHQGHXW WKH
+E DT J2 +E2 DT
+RZHKDUPRJORELQ FRPELQHV PRUH DQGLQGLQ LQ WKH & 2
& 2 D FRPSHWLQJ LQ SUHWHQVLRQ\ EHKDORZTXD VHW XS
+E DT & 2 J+E& 2 DT
7K+ & 2 HTXLOLEULXP KDVHTXLPXQKE K LXR KFR QVWXQV LQ WKH
DQG VR LQ WKH SUHWHQVLRQ\ RH & 2 WR EHKDORZTXD HQJWWR2
+E2 DT & 2 J+E& 2 DT J
& RQVHTXHQWO\ & 2 KHVHTXQV LQ WKH QHFHVVDU
F 1RQ IDWDO & 2 SRLVHQ LQ WKH LQVXQV LQ WKH LQVXQV LQ WKH
DT E & 2 J+E& 2 DT J
WR VKLIW WR WKH OHIWRQV LQ WKH LQVXQV LQ WKH LQVXQV LQ WKH

I 7KH &)33 UHIO ~~WFLVRQ~~ ~~W~~ ~~K~~ ~~M~~ ~~Z~~ ~~H~~ ~~W~~ ~~Q~~ ~~U~~ ~~I~~ ~~K~~ ~~H~~ ~~V~~ ~~K~~ ~~R~~ ~~O~~ ~~W~~ ~~E~~ ~~R~~ ~~Q~~ ~~H~~ ~~M~~ ~~U~~ ~~W~~ ~~K~~
LQWHUPROHFXODU DWWUD~~F~~ ~~W~~ ~~L~~ ~~Z~~ ~~K~~ ~~Q~~ ~~F~~ ~~M~~ ~~K~~ ~~M~~ ~~S~~ ~~X~~ ~~J~~ ~~K~~ ~~H~~ ~~B~~ ~~L~~ ~~V~~ ~~S~~ ~~H~~ ~~H~~ ~~A~~
KDYHK~~W~~ ~~J~~ ~~K~~ ~~H~~ ~~U~~ ~~E~~ ~~J~~ ~~B~~ ~~F~~ ~~D~~ ~~X~~ ~~V~~ ~~H~~ ~~G~~ ~~X~~ ~~H~~ ~~W~~ ~~R~~ ~~S~~ ~~R~~ ~~O~~ ~~I~~ ~~D~~ ~~S~~ ~~J~~ ~~H~~ ~~V~~ ~~W~~ ~~Q~~ ~~E~~ ~~H~~ ~~I~~ ~~D~~ ~~E~~ ~~R~~ ~~K~~ ~~X~~ ~~S~~ ~~K~~ ~~H~~
PROHFXO~~W~~ ~~U~~ ~~V~~ ~~Q~~ ~~J~~ ~~H~~ ~~U~~ ~~L~~ ~~Q~~ ~~W~~ ~~H~~ ~~U~~ ~~P~~ ~~R~~ ~~O~~ ~~K~~ ~~I~~ ~~F~~ ~~Q~~ ~~O~~ ~~S~~ ~~H~~ ~~O~~ ~~V~~ ~~D~~ ~~W~~ ~~G~~ ~~L~~ ~~H~~ ~~D~~ ~~H~~ ~~W~~ ~~L~~ ~~R~~ ~~Q~~
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%RWK DFLGV KDYH WKH VDPH PROGFWRQDUBJURXS D
WIGHWHUPLQLQJ IDFWGRHFXQDUKDWQWQWUHLHQQWLV WKH
DURXQG WKH & (GRXEODHEDGDDVDQJHPHQW DQG EUD
DFLG kadsDDUDQJHFNHQW FDXVHsGUEUDQJHPHQW LQ HU
DFLG SUHYHQWV NWQJPWGHFWGHV DVFHWHRWLOHVRU
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4XHVWLRQ PDUNV
D 6LQFH WKH FRPSRXQG VFSUHGHQWQHWRHFGDFQWV
E 7KH IXHO ZRXOG EH WKH&ELRQVPHQ PHWK\O ROHDW
&RPEXVWLRO HTXDWLRO

+ & 22 &+ O 2o & 2 J 2+ J ①O
 F 0XFK RI WKH FDUERKHG UFDXWV LEH DFKRFDXGLRWH DUD Q GERW
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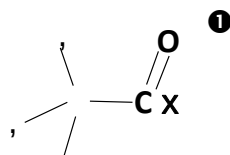
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VLWH PRGLI\LQJ LVEWUHQDIEOHRWEHQG EWRQ GWEVRDMK
OHFHVVDU\IRU UHDFWLRO LV DFWLYDWHG

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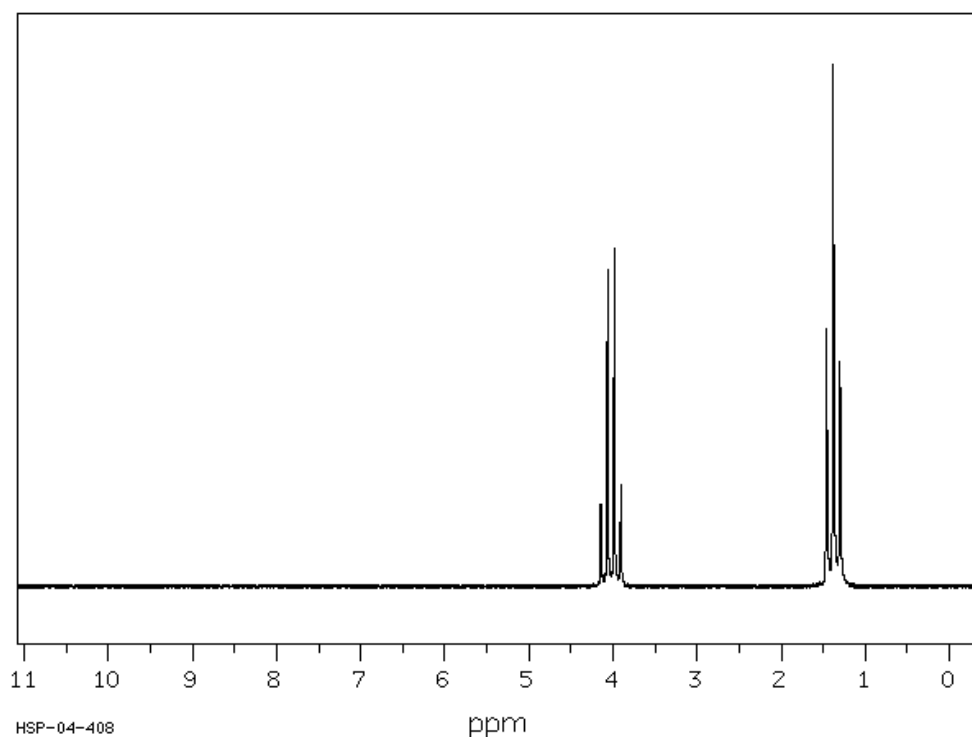
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4XHVWLRQ PDUNV
D &+&+2+ D~~T~~ &+&+2 DT DT ① H
7KH R[LGDWLRQYRIVHWKH QROV L QYRKQW FZLHQK WRQIVL V
dehydrogenase ① QDPH RI W①KH HQ] \PH
E 1\$' DFWVRQVQVQVQ G LV UHGXFHFGJHQJDQDFQJUGLQJ WR
1\$' DT BT oH1\$'+ D①

F &+ &2x



G &+ 16 « IURP &+ 161 &+&+ ①
H 'LVXOILUDP LV DRQPPXQWUZEDQ PR&+U HURKSDOHQW &+
7KH 105 VSHFWUXPWZLQVHFVQVRBQWQDQSVRRQ &+
① DQG XDUWHVQ ① +DFFRUGLQJ WR WKH Q UXOH



I VHWKDQRO LQ P/ JODVV RI ZLQH ①
P/
m HWKDQRO LQ P/ JODVV RI ZLQH
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①
7LPH WR SURFHVV HWKDQRO LQ JPSHJQBRXURI ZLQH
KR①UV
J &+ 2 D~~T~~ &+&+2+ DT ①
)HUPHQWDW[LRQKHVFDQ HQHFLWWRQFHKGFDVQSRWGXLVVLS
WKH FDWDO\ VW PD\ EHFDFWBLQYHILHFVQYHQVLPQHFHQG H
DOO SURWHLQV FDQ GHQDWDQGH IDQWKKLHKS WWHVISEHEDWR
FDXVLQJ WKHWDFZHL YCH①VWHIHFWLYH

4XHVWLRQ PDUNV
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1
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& V 2 2 J o + J &2
7K&2 SURGX L Q H V K H S U R F H Q K R L X K B F J O V I S R V V L E O H V K R
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)RU &&6 WR EH IHDVLEOH
VXLWDEOH WVRUDJH P R F W E R Q G R H W K I H R O R J L F D O
IRUPDWLRQV GHHS XQG H U J U R X Q G
V L Q F Z R X O G E H V W R U H G X Q G H U S U H V V X U H W K H O R F
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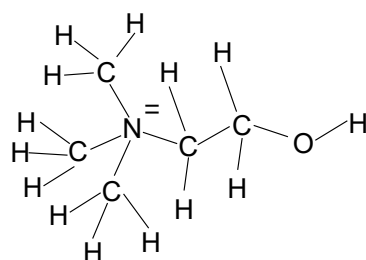
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D Q \ S R V V L E O H L J Q L W L R Q V R X U F H V
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S U H V V X U L V H 1 F R Q W D L Q H U V

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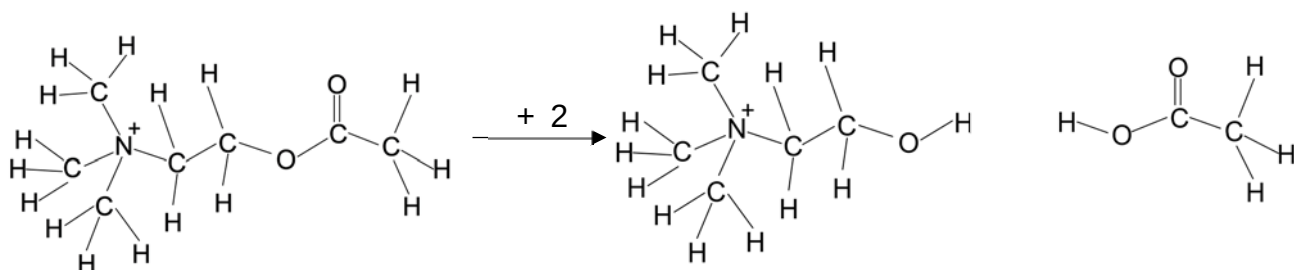
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R W K H U W K D Q P L Q L P D O D P R Q D W V Q R S X U H Z D W H U P L Q
H O H F W U R O \ W D F F R Q G X F W L R Q
L L 8 H O H F W U L F D O H Q H U R O R E W D O Q M G W I R G R V I V H R W D H H
G L O X W H D T X H R X V V R O X V L R Q R I V R G L X P F K O R U L G H
& D W K R G H 2 H D F W D R Q + J 2 D T

I , Q F D O I L U H G S I Z H H W J M L D W L R Q W D W H D F K H Q H U J \ W U
R Q O \ D E R X W S H U P L F H Q W H R Q H W K H L F K D E Q Y H H W O H F W W R F X
H Q H U J \ X H O F H O O V D U H I D U P R U H H I I L F L H Q W F K H P D X D O V
H Q H U J \ W R H O H F W U L F D O H Q H U J \ R F F X U V L Q D V L Q J O H

4XHVWLRQ PDUNV
D L &+ 1 &+&+2+ ①



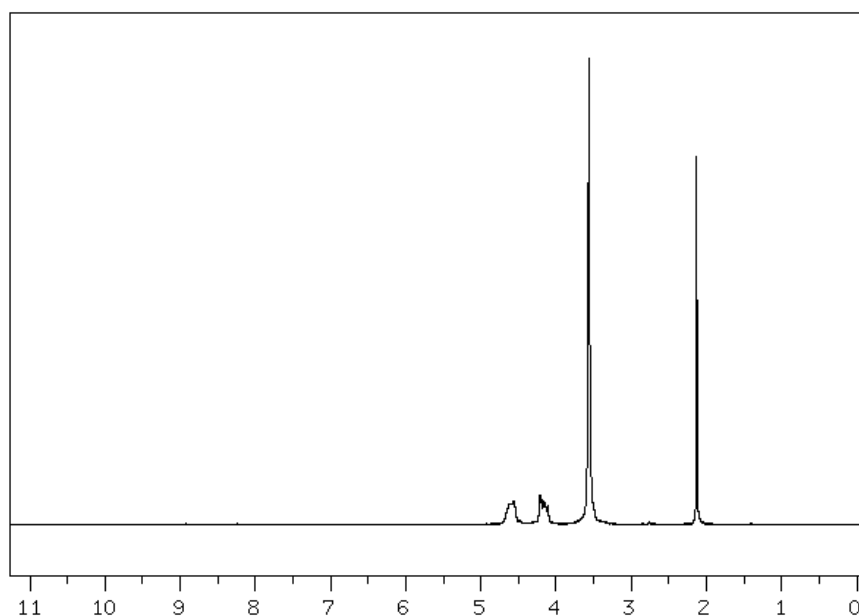
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FDUERQ DWRPV DV LQ WKH DQPLRQXPQLDQW LV ERQ
K\GURJHQ DWRPV
7KH LQ FRXUVH TXDWHU\QDZURVWRXWHV
TXDWHUQDU\ VW\XFRPXLHQ DWLHRQV\W\WRQRK DQW S
OLQNHG WRJHWKHU DQGH\SRUWHQV\XQ DV KDHP
E 7KH K\GURO\VLV RI DFHW\OFKROLDQH RTFXDWLRQ FRUG



DFHW\OFKROLQH

FKROLQH

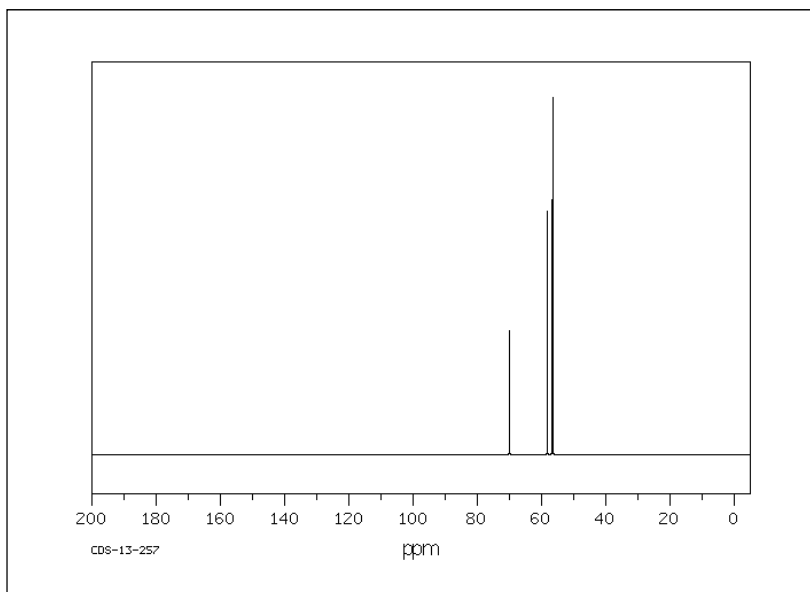
L 6SHFWUXP



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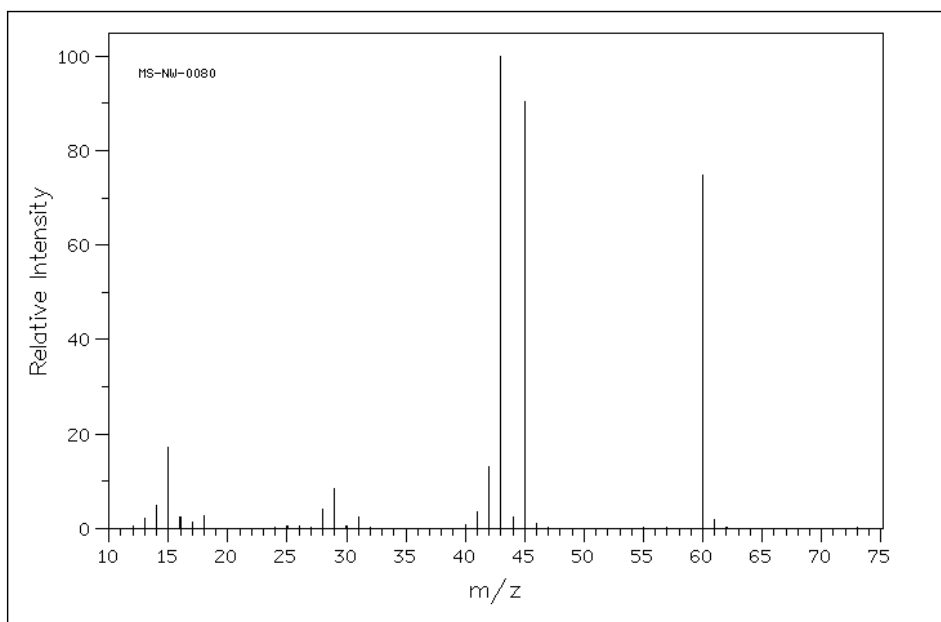
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6SHFWUXP



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FDERQ HQYHURQPHQWV

6SHFWUXP



7KLV LDVWKMSHFWUXP RIDFMKLOFRHFLSDUHQW SHD
P] FRUUVSRQGV ZLWK WK&22+RHHFXODU PDV
LL 7KH SHDN ZLWK UHODWLYHEDQWSDQWV DWVRFLD
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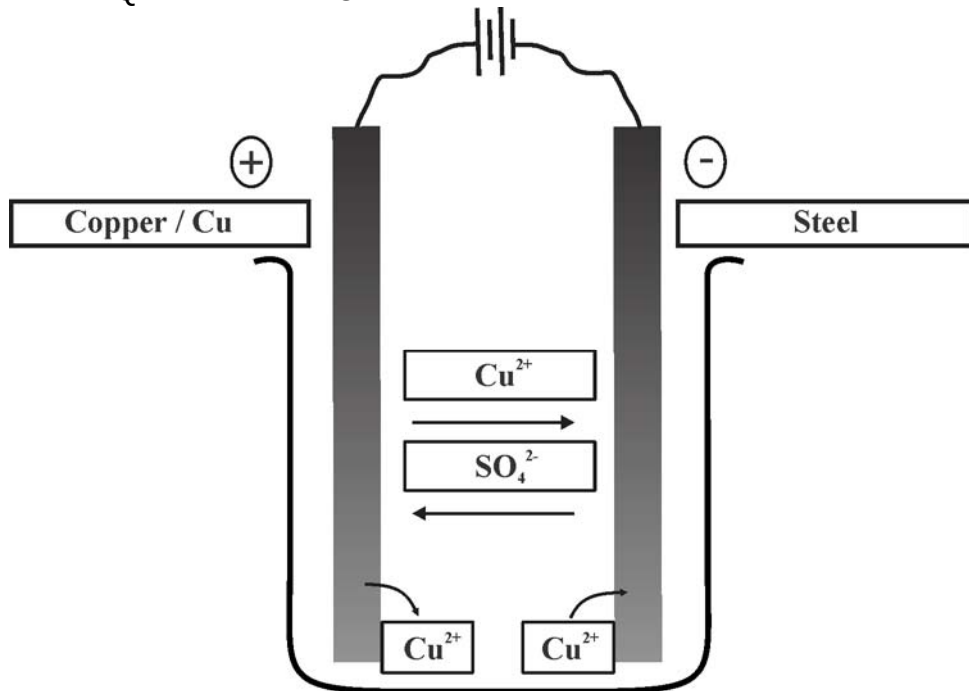
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G 3UDOLGR[LPH EULGH &
 + 1 2 & UHTXLHG LQ PLQXWHV PJ NJ
 + 1 2 & UHTXLHG PL J J PRO
 + 1 2 & UHTXLHG LQ PROXWHV J
 5DWH DGPLQVPHRGXR

4XHVWLRQ
 D

PDUNV



1 IRU FRUUHFW HOHFWURGH VLJQV
 1 IRU FRUUHFW ODEHOOLQJ RI HOHFWURGHV
 1 IRU FRUUHFW LVSFHWHV QGHQHOHFWURO\WH
 E , QGHSHQGH FWUHQV EOH ±
 'HSHQGHQW PDVLRDIE & HSRDQWHGQ DVV RI SODWH
 F 7KUHH IURP
 (OHFWURO\WH FRQFHQWUDWLRQ ZHOHQWOREWURGHV
 WHPSHUDWXUH DQG WLP
 G HIILFLHQF\ > DFWXDO & XGHRUHLWLFDO P & X GHS
 5HGXFWRQ KDODHTXDWLRQ & X
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 HIILFLHQF\ DFWXDO PDVV WKRUHLWLFDO PD
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H 3R VVLEOH UH D V R Q V
 0 D V X G G L G Q R W D C W H G W K H G H F F A S S H G G S S O U L R U W R Z H L J K
 & O D U L V V H D F F G G V H R Q W D R O W K U H G R K S H R Q I G W M L Q Q F R A S I S H H U F R Z
 S O D W H G H O H F W U R G H
 6 R P H R I W K H F R S S H O D G H S R V L W O H F G V G R G H Q Z D G U R I Q G L
 I D T & L V X L P X O W D Q H R X V O \ S U R G X F H G F D W K W R G H H D Q R G
 J , Q W K H R U L J L Q D R I B R S S H V L S U R G R R H H G V D W R W K H P D W Q R V
 W R W K H H O H F W U R G H W R O U B B P E Y H G F N G L X Q U L Q K G W A H R U B B
 F K D Q J H L Q W K H B B H F W K U R G M R I D V L W R R I I F R B S W K U H R Q Q G
 : K L O V W W K L V Z R X V G H E H I O W K V W R R S S Q J K H D Q E G H R Z D V D Q G
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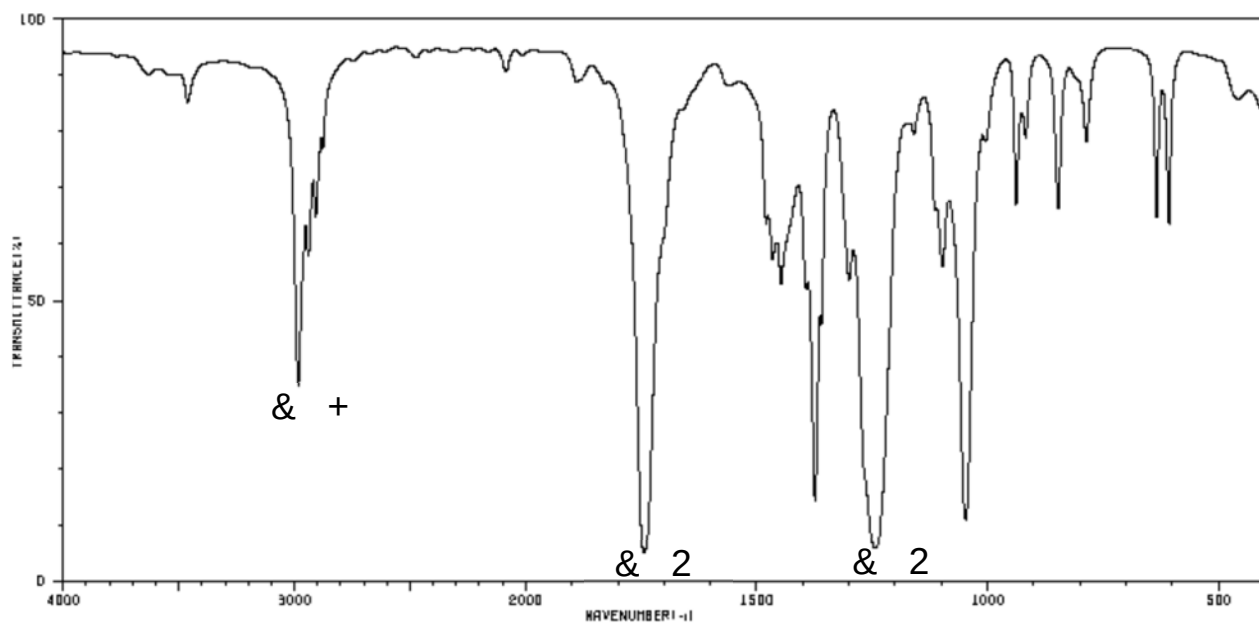
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 D ' X U L Q J W K H G L V F K D U R H L G W K H W W U B Q D H R V Q U G V V L W H K G W R K V
 6 L Q F H D T H L V D Z H W D N Q W W K G Q F = Q T V P W K W Q E B H D V W U R Q
 R [L G D Q W W K D Q = Q
 ' X U L Q J G L V F K D U R H L G Q V V H G O H F W W K H G H O V D T Q & H V
 U H G X F H G D H W M F K M U R G H G H U D J S K D S K L W R R F R P D S R V L W H
 S X P S H G R Y H U W K B Q G I B O H & W T U R I G V S X P S H G R Y H U W K H
 H O H F W U R G H

= Q V Q D T H
 & H T o H & H D T
 E ' X U L Q J U H F K D U J L S Q V E Q H V G I R Q G W K H X H W R O H F W U R G H
 D T o H Q Q
 F E q R [L G D Q W K Q D H G X F O V D Q W q & B Q I H F H Q O = Q
 E q & H & H $\pm$ from Table 2 of the VCE Chemistry Data Book
 E q & H & H
 E q & H & H $\pm$

G , Q D F R Q Y H Q W L R Q W O H W H F K D U J H O N E Q H Q E F W K D H Q F M O D U H R Z
 W K H H G R [I O R Z E D W W H U \ W K H U H D F W D Q W G S X I P S H W R U Q
 D V U H T X L U H G D V K D S S R I Z H Y G E F W H O F D H O O W F K D U J L Q J L
 F K D U D F W H U L V V L F R I X H O F H O O V

H L * H Q H U D O U H D F W L R Q + S O V Z K Z K Q U R R R W K H U R U J D Q L F
 L Q Y R O Y H G L V
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 P D V V V S H F W K M P U H Q W L R Q S H D N Q E W H S H D N D W
 m z 1
 + 105 V S H F W K M P U H H K I G U R J H Q Z L W K L D R Q P H Q W
 T X D U W H W V L Q S O H W W W Q U L S O M W W H U Q
 7 K L V G D W D L V F R Q W L K V O H Q W K B Q V R D + W H O S + H V W H U
 M U & + & 2 2 & + & +
 r m z L V F R Q V L & + W H 2 Q W D Z L P H Q W
 r W K U H H G L I I H U H Q W K I G U R J H Q H Q Y L U R Q P H Q W V
 r T X D U W H W L F R Q V L S O M W W Q W 1 Z L W K
 \$ O V R V G J Q D O S S W L V F R Q V & 2 W H Q W Z L W K &
 V L J Q D O D S V S P L V F R Q V L V W H Q W Z L W K 5 & 2 2 &

L L Table 84 in the VCE Chemistry Data Book W R L G H Q W L I \ S H D N V I R
2 D Q G & 2 H V W H U V E R Q G V



① I R U D O O F R U U H F W

(Q G R I 6 X J J H V W H G \$ Q V Z H U V