CHAPTER 5

RESULT AND DISCUSSION

5.1 The information of preliminary investigation of solid reactions.

A total of 814 solid-solid reactions, which were selected from the permutations of 170 reactants by observing the colour appearence of their products at the range 25°C to 35°C of room temperature, were tabulated in Table 5.1 with some properties*. But the instantaneous reaction was left to be understood without any notice.

For the important contents of these reactions, see appendix II

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* R_1 - 1st reactant

R_2 - 2nd reactant

P - product

P_1 - 1st product

P_2 - 2nd product

P_n - nth product

dk - dark

hygr.- hygroscopic

Table 5.1 Solid-solid reactions of inorganic compounds

R_2 \ R_1	$AgNO_3$ white	R_2 \ R_1	$AgNO_3$ white	R_2 \ R_1	$AgNO_3$ white
As_2S_3 orange	p-dk.brown time-22hrs	Cu_2Cl_2 yellow--green	p_1-green p_2-pale blue time-20hrs.	K_2CrO_4 yellow	p-black time-16hrs
$BaBr_2.2H_2O$ white hygs	p-yellow--gray	$Cu(CN)_2$ yellow--gray	p_1-pale blue p_2-dk.gray time-20hrs	KCN white	p-pale blue -gray time-22hrs
$BiCl_3$ white hygs	p_1-yellow- p_2-gray time-20hrs	Cu_2I_2 white	p_1-black p_2-green time-18hrs	KCNO white	p-dk.brown time-20hrs
$CaCl_2.2H_2O$ white	p-gray time-22hrs	$Fe(NH_4)_2.(SO_4)_2.6H_2O$ pale green--blue	p_1-yellow p_2-brown time-18hrs.	$KC_2H_3O_2$ white	p-dk.gray time-20hrs
$Ca(OH)_2$ white	p-dk.gray time-22hrs	$Hg.K.(CN)_3$ white	p_1-black p_2-gray time-20hrs	$K_2Cr_2O_7$ red-orange	p-dk.violet time-16hrs
$Ca_3(PO_4)_2$ white	p-dk.gray time-22hrs	Hg_2S red	p-brown time-20hrs	$K_3Fe(CN)_6$ dk. orange	p-brown time-16hrs
CaS white	p-black time-24hrs	KBr white	p-yellow time-20hrs	$K_4Fe(CN)_6.3H_2O$ pale yellow	p-green--blue time-16hrs
$CuCl_2.2H_2O$ green-blue	p_1-green p_2-blue time-18hrs	KCl white	p-pale blue-gray time-18hrs	KF white hygs	p-black

Table 5.1 (Continued)

R_2 \ R_1	$AgNO_3$ white	R_2 \ R_1	$AgNO_3$ white	R_2 \ R_1	$AgNO_3$ white
$KHCO_3$ white	p-dk gray time 20hrs	$NaI.2H_2O$ white hygs	p-pale yellow	NH_4I dk.yellow hygs	p-pale yellow time 1hrs
KI white hygs	p-yellow time 16hrs	NaSCN white hygs	p_1-dk. yellow p_2-gray time 22hrs	$(NH_4)_2SO_4$ white	p-pale blue-gray time 22hrs
$MnCl_2.4H_2O$ rose hygs	p-gray time 18hrs	$Na_2SO_3.7H_2O$ white hygs	p-dk brown	$SbCl_3$ white hygs	p_1-gray p_2-yellow time 20hrs
NaCl white	p-pale blue-gray time 18hrs	NH_4Cl white	p-pale blue-gray time 19hrs	$SrCO_3$ white	p-dk gray time 20hrs
Na_2CO_3 white	p-pale blue-gray time 18hrs	$(NH_4)_2CO_3$ white hygs	p_1-yellow p_2-gray time 1hrs	$Sr(OH)_2.8H_2O$ white	p-black time 10hrs
$Na_2C_2O_4$ white	p-orange yellow time 18hrs	$(NH_4)_2CrO_4$ dk.yellow	p-black time 5min	$SnCl_2.2H_2O$ white	p-red-brown time 10min
$Na_2HAsO_4.12H_2O$ white	p-dk.brown time 24hrs	$(NH_4)_2C_4H_4O_6$ white	p-black time 20hrs	TiO_2 white	p-dk.gray time 12hrs
$NaH_2PO_4.12H_2O$ white	p-yellow time 16hrs	NH_4F white hygs	p_1-yellow p_2-gray time 1hrs	$ZnCl_2$ white hygs	p-gray time 16min

Table 5.1 (Continued)

R_2 \ R_1	Ag_2SO_4 white
$BaBr_2.2H_2O$ white hygs	p-yellow-gray
CaS white	p-black time 22hrs
Cu_2Cl_2 yellow-green	p_1-dk.green p_2-pale blue time 15hrs
CdI_2 white	p-yellow time 24hrs
Cr_2O_3 dk.red hygs	p-black time 15hrs
PbI_2 yellow	p-black time 18hrs

R_2 \ R_1	$AgNO_2$ white
$Na_2HASO_4.12H_2O$ white	p-dk.brown time 22hrs
$NaH_2PO_4.12H_2O$ white	p-yellow time 20hrs
ZnO white	p-black time 2hrs

R_2 \ R_1	$Al(NO_3)_3.9H_2O$ white hygs
$CoCl_2.6H_2O$ red-violet hygs	p-purple time 5min
$CoF_2.4H_2O$ pink	p-red time 10min
CuO black	p-red-white time 20hrs
Hg.K.(CN)$_3$ white	p-pale blue time 20hrs
HgO orange	p-white time 21hrs
K_2CrO_4 yellow	p-orange
KCN white	p-brown time 20hrs
$K_3Fe(CN)_6$ dk.orange	p-dk.green time 18hrs
$K_4Fe(CN)_6.3H_2O$ pale yellow	p-blue

Table 5.1 (Continued)

R_2 \ R_1	$Al(NO_3)_3 \cdot 9H_2O$ white hygs	R_2 \ R_1	$Al(NO_3)_3 \cdot 9H_2O$ white hygs	R_2 \ R_1	$Al(NO_3)_3 \cdot 9H_2O$ white hygs
$LiC_7H_5O_3$ white	p-blue hygs time 15hrs	NaSCN white hygs	p_1-red p_2-yellow	PbI_2 dk.yellow	p-dk.violet time 16hrs

R_2 \ R_1	$AlPO_4$ white	R_2 \ R_1	$AlPO_4$ white	R_2 \ R_1	$AlPO_4$ white
Cr_2O_3 dk.red hygs	p-black	$CuCl_2.2H_2O$ blue-green	p-yellow green time 22hrs	Na I.$2H_2O$ white hygs	p-red brown time 16hrs
$CoCl_2.6H_2O$ red-violet hygs	p-blue purple time 20hrs	KI white hygs	p-pale brown time 24hrs		

R_2 \ R_1	$BaBr_2.2H_2O$ white hygs	R_2 \ R_1	$BaBr_2.2H_2O$ white hygs	R_2 \ R_1	$BaBr_2.2H_2O$ white hygs
$BiCl_3$ white	p-yellow time 5min	$CuCl_2.2H_2O$ blue-green	p-black time 10min	$Hg_2(NO_2)_2$ white hygs	p-brown time 23hrs
$Bi(NO_3)_3 \cdot 5H_2O$ white	p-pale yellow time 21hrs	$CuSO_4$ blue	p-black time 10min	Hg_2O orange	p-pale brown time 21hrs
Cr_2O_3 dk.red hygs	p-black	$Fe_2(C_2O_4)_3 \cdot 5H_2O$ green-yellow	p_1-dk. yellow p_2-brown time 10min	Hg_2SO_4 white	p-black time 20hrs

Table 5.1 (Continued)

R_2 \ R_1	$BaCrO_4$ dk.yellow hygs
$BaCO_3$ white	p-black time 1hrs
$Na_2C_4H_4O_6 \cdot 2H_2O$ white	p-black
NaSCN white hygs	p-black

R_2 \ R_1	$BaCl_2.2H_2O$ white
$CoCl_2.6H_2O$ red-violet hygs	p-blue-purple time 22hrs
$Co(NO_3)_2 \cdot 6H_2O$ red hygs	p-blue-purple time 22hrs
$CoSO_4.7H_2O$ red	p-purple time 18hrs
$CuSO_4$ blue-white	p-green time 20hrs
$CuSO_4.5H_2O$ blue	p-green time 15hrs
$Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$ pale blue-green	p-pale yellow time 18hrs

R_2 \ R_1	$Ba(C_2H_3O_2)_2$ white
$CrCl_3.6H_2O$ dk.green hygs	p-blue time 20hrs
$CoCl_2.6H_2O$ red-violet hygs	p-purple time 18hrs
$CuCl_2.2H_2O$ blue green	p-dk.green time 20hrs

R_2 \ R_1	BaO_2 white
Cr_2O_3 dk.red hygs	p-black
$CoCl_2.6H_2O$ red-violet hygs	p-black time 10min
$Co(NO_3)_2 \cdot 6H_2O$ red hygs	p_1-brown p_2-green time 10min

Table 5.1 (Continued)

R_2 \ R_1	BaO white
CdI_2 white	p-yellow--brown time 19hrs.
$Co(NO_3)_2 \cdot 6H_2O$ hygs.	p-blue--violet time 5min.

R_2 \ R_1	BaO white
$HgCl_2$ white	p-brown time 10min.
$MnCl_2 \cdot 4H_2O$ rose hygs.	p-brown time 10min.

R_2 \ R_1	BaO white
$MnCO_3$ brown	p-brown time 16hrs.
$SnCl_2 \cdot 2H_2O$ white hygs.	p_1-yellow p_2-brown time 24hrs.

R_2 \ R_1	$Ba(OH)_2 \cdot 8H_2O$ white
$Co(NO_3)_2 \cdot 6H_2O$ red hygs.	p-black time 30min.
$HgCl_2$ white	p-brown time 20min.

R_2 \ R_1	$Ba(OH)_2 \cdot 8H_2O$ white
$Hg_2(NO_2)_2$ white hygs.	p-brown time 20min.
$MnCl_2 \cdot 4H_2O$ rose hygs.	p-brown time 20min.

R_2 \ R_1	$Ba(OH)_2 \cdot 8H_2O$ white
$MnSO_4 \cdot 4H_2O$ pink hygs.	p-brown time 24hrs.

R_2 \ R_1	BaS white gray
$BiCl_3$ white hygs.	p-yellow--brown time 20min.
Cr_2O_3 dk.red hygs.	p-black

R_2 \ R_1	BaS white gray
$Co(NO_3)_2 \cdot 6H_2O$ red hygs.	p_1-pink p_2-brown time 1hrs.
$CuCl_2 \cdot 2H_2O$ blue-green	p-black time 10min.

R_2 \ R_1	BaS white gray
KF white hygs.	p-gray time 5min.
$MnCl_2 \cdot 4H_2O$ rose hygs.	p-gray time 20hrs.

Table 5.1 (Continued)

R_2 \ R_1	$BaSO_4$ white	R_2 \ R_1	$BaSO_4$ white	R_2 \ R_1	$BaSO_4$ white
KI white hygs.	p-yellow time 18hrs.	$NaI.2H_2O$ white hygs.	p-yellow time 20hrs.	NH_4I dk.yellow hygs.	p-yellow time 20hrs.

R_2 \ R_1	$BiCl_3$ white	R_2 \ R_1	$BiCl_3$ white	R_2 \ R_1	$BiCl_3$ white
CaS white	p-yellow time 18hrs.	KI white hygs.	p_1 red p_2-yellow time 24hrs.	$NaI.2H_2O$ white hygs.	p_1-orange p_2-black p_3-yellow time 24hrs.
Hg_2SO_4 white	p-yellow time 20hrs.	$MnCO_3$ brown	p_1-brown p_2-white time 22hrs.	$SrCO_3$ white	p-yellow time 15hrs.
$Hg.K.(CN)_3$ white	p-blue-white time 20hrs.	NaSCN white hygs.	p-orange	$SnCl_2.2H_2O$ white	p_1-gray p_2-yellow time 23hrs.

R_2 \ R_1	$CaBr_2.6H_2O$ white hygs.	R_2 \ R_1	$CaBr_2.6H_2O$ white hygs.	R_2 \ R_1	$CaBr_2.6H_2O$ white hygs.
Cr_2O_3 dk.red hygs.	p-black	$CuCl_2.2H_2O$ blue-green	p-black	$CuSO_4$ blue-white	p-black
$CoCl_2.6H_2O$ red-violet hygs.	p-blue	$CuCO_3.Cu(OH)_2$ pale blue--white	p-black		

Table 5.1 (Continued)

R_2 \ R_1	$Bi(NO_3)_3 \cdot 5H_2O$ white	R_2 \ R_1	$Bi(NO_3)_3 \cdot 5H_2O$ white	R_2 \ R_1	$Bi(NO_3)_3 \cdot 5H_2O$ white
$NaI.2H_2O$ white hygs.	p-red orange time 15hrs.	NaSCN white hygs.	p-dk.yellow	$SnCl_2.2H_2O$ white	p-orange--yellow

R_2 \ R_1	Bi_2O_3 yellow	R_2 \ R_1	Bi_2O_3 yellow	R_2 \ R_1	Bi_2O_3 yellow
$CoCl_2.6H_2O$ red-violet hygs.	p-gray time 16hrs.	$Sr(NO_3)_2 \cdot 4H_2O$ white	p-pale brown time 20 hrs.	$SnCl_2.2H_2O$ white	p-dk.gray time 18hrs.

R_2 \ R_1	BiOCl white	R_2 \ R_1	BiOCl white	R_2 \ R_1	BiOCl white
KI white hygs.	p_1-red p_2-yellow time 15hrs.	NaSCN white hygs.	p-orange -yellow	Na I $2H_2O$ white hygs.	p-yellow time 1hrs.

R_2 \ R_1	$CaCl_2.2H_2O$ white	R_2 \ R_1	$CaCl_2.2H_2O$ white	R_2 \ R_1	$CaCl_2.2H_2O$ white
$CoCl_2 6H_2O$ red-violet hygs.	p_1-blue	$CoSO_4.7H_2O$ red	p-blue time 12hrs.	$CuSO_4$ blue-white	p-green
$Hg_2(NO_2)_2$ white	p-dk.gray time 24hrs.	KCN white	p-brown time 18hrs.	$K_3Fe(CN)_6$ dk.orange	p-pale time 18hrs.

Table 5.1 (Continued)

R_2 \ R_1	CaC_2O_4 white	R_2 \ R_1	CaC_2O_4 white	R_2 \ R_1	CaC_2O_4 white
$CuSO_4$ blue-white	p-dk.brown time 22hrs.	$CuSO_4.5H_2O$ blue	p-dk.brown time 22hrs.	NaSCN white hygs.	p-orange time 1hrs.

R_2 \ R_1	$Ca(C_2H_3O_2)_2.2H_2O$ white	R_2 \ R_1	$Ca(C_2H_3O_2)_2.2H_2O$ white	R_2 \ R_1	$Ca(C_2H_3O_2)_2.2H_2O$ white
$CoCl_2.6H_2O$ red-violet hygs.	p-black	$CuCl_2.2H_2O$ blue green	p-green time 5min.	Cu_2Cl_2 yellow-green	p-dk.green time 22hrs.
$CuSO_4$ blue-white	p-green--yellow	$Fe(NO_3)_3.H_2O$ yellow-brown hygs.	p-dk brown		

R_2 \ R_1	$Ca(OH)_2$ white	R_2 \ R_1	$Ca(OH)_2$ white	R_2 \ R_1	$Ca(OH)_2$ white
Cr_2O_3 dk.red hygs.	p-yellow time 1hrs.	$Co(NO_3)_2.6H_2O$ red hygs.	p-black time 15min.	$CuBr_2$ dk.brown hygs.	p-blue time 20hrs.
$CuCl_2.2H_2O$ blue green	p-green time 15min.	$Cu(NO_3)_2.6H_2O$ blue hygs.	p-green time 1hrs.	$Hg_2(NO_2)_2$ white hygs.	p-red--brown
$HgCl_2$ white	p-black time 24hrs.	$MnCl_2.4H_2O$ rose hygs	p-brown time 20hrs.	$MnSO_4.4H_2O$ pink hygs.	p-brown time 22hrs.

Table 5.1 (Continued)

R_2 \ R_1	CaS gray-white	R_2 \ R_1	CaS gray-white	R_2 \ R_1	CaS gray white
Cr_2O_3 dk.red hygs.	p-black time 30min.	$CoCl_2.6H_2O$ red-violet hygs.	p-brown time 22hrs.	$CoF_2.4H_2O$ pink	p-brown time 20hrs.
$CuBr_2$ dk.brown hygs.	p-brown time 20hrs.	$CuCl_2.2H_2O$ blue-green	p-pale green time 22hrs.	$Fe_3(PO_4)_2.8H_2O$ dk - green	p-black time 30hrs.
$Fe(NO_3)_3$ brown hygs.	p-black	$Hg_2(NO_2)_2$ white hygs.	p-dk. gray time 20hrs.	NH_4I dk.yellow hygs.	p-yellow time 20hrs.
$Pb(C_2H_3O_2)_2$. $3H_2O$ white	p-black time 22hrs.	$SbCl_3$ white	p-orange time 21 hrs.	$SnCl_2 2H_2O$ white	p-dk.gray time 1hrs.

R_2 \ R_1	CaF_2 white	R_2 \ R_1	CaF_2 white	R_2 \ R_1	CaF_2 white
Cr_2O_3 dk.red hygs.	p-yellow time 20hrs	$CuBr_2$ dk.brown hygs	p-brown time 22hrs.	$CuCl_2.2H_2O$ blue green	p-green time 22hrs

R_2 \ R_1	$CdBr_2$ white	R_2 \ R_1	$CdBr_2$ white	R_2 \ R_1	$CdBr_2$ white
Ag_2SO_4 white	p-black time 20hrs.	Cr_2O_3 dk.red hygs.	p-black	$Na_2S_2O_3.7H_2O$ white hygs.	p-yellow time 22hrs.

Table 5.1 (Continued)

R_2 \ R_1	CaO white	R_2 \ R_1	CaO white	R_2 \ R_1	CaO white
$Co(NO_3)_2 \cdot 6H_2O$ red hygs.	p-dk.violet -green time 30min.	$CuBr_2$ red-brown	p-pale blue time 18hrs.	$CuCl_2 \cdot 2H_2O$ blue-green	p_1-pale blue p_2-green time 12hrs.
$HgCl_2$ white	p-red brown time 23hrs.	$MnCl_2 \cdot 4H_2O$ rose hygs.	p_1-black p_2-yellow time 23hrs.	NH_4I dk.yellow hygs.	p-black time 1hrs.

R_2 \ R_1	CdS orange	R_2 \ R_1	CdS orange	R_2 \ R_1	CdS orange
$Cr_2(SO_4)_3 \cdot 18H_2O$ dk.green hygs.	p-brown time 24hrs.	$CuCl_2 \cdot 2H_2O$ blue-green	p-dk.yellow time 30hrs. min.	$Hg.K.(CN)_3$ white	p-black time 22hrs.
$Hg_2(NO_2)_2$ white hygs.	p_1-orange p_2-black	$SnCl_2 \cdot 2H_2O$ white	p-black time 23hrs.		

R_2 \ R_1	$CoSO_4 \cdot 7H_2O$ red-white	R_2 \ R_1	$CoSO_4 \cdot 7H_2O$ red-white	R_2 \ R_1	$CoSO_4 \cdot 7H_2O$ red-white
$Hg.K.(CN)_3$ white	p-green time 20hrs.	KCN white	p-brown time 20hrs.	KCNO white	p-blue time 20hrs.
$KC_2H_3O_2$ white	p_1-blue p_2-purple time 1hrs.	$NaH_2PO_4 \cdot 12H_2O$ white	p-purple time 20hrs.	$Na_2S_2O_3 \cdot 7H_2O$ white hygs.	p-blue time 1min.

Table 5.1 (Continued)

R_2 \ R_1	$CoCl_2.6H_2O$ red-violet hygs.	R_2 \ R_1	$CoCl_2.6H_2O$ red-violet hygs.	R_2 \ R_1	$CoCl_2.6H_2O$ red-violet hygs.
$Ca(NO_3)_2.4H_2O$ white hygs.	p-blue	$CuCl_2.2H_2O$ blue-green	p-brown time 23hrs.	Cu_2Cl_2 yellow-green	p-dk.brown time 30min.
$CuSO_4$ blue-white	p-green time 20hrs.	$CuSO_4.5H_2O$ blue	p-green -yellow time 20hrs.	$Hg.K.(CN)_3$ white	p-brown time 20hrs.
$Hg_2(NO_2)_2$ white hygs.	p-orange red time 10hrs.	HgO orange	p-purple time 18hrs.	Hg_2SO_4 white	$p_1$pink p_2-pink--purple time 22hrs.
KBr white	p-purple time 1hrs.	KCNO white	p-blue time 10min.	$K_2Cr_2O_4$ yellow	p-brown time 30min.
KCl white	p-blue--purple time 1hrs.	$K_2C_2O_4.H_2O$ white	p-pink--purple time 1hrs.	KCN white	p-brown time 10min.
$KC_2H_3O_2$ white	p-blue purple time 1hrs.	$K_2Cr_2O_7$ red-orange	p-black time 20hrs.	KF white hygs.	p_1-blue purple p_2-red time 1hrs.
$KHCO_3$ white	p-purple time 1hrs.	KNO_3 white	p-blue -purple time 1hrs.	K_2SO_4 white	p-blue--violet time 20hrs.
$Mg(BO_2)_2.8H_2O$ white	p-pink--purple time 23hrs.	$MgC_2O_4.2H_2O$ white	p-pink--violet time 23hrs.	$Mg_3(PO_4)_2.4H_2O$ white	p-purple time 1hrs.

Table 5.1 (Continued)

R_2 \ R_1	$CoCl_2.6H_2O$ red-violet hygs.	R_2 \ R_1	$CoCl_2.6H_2O$ red-violet hygs.	R_2 \ R_1	$CoCl_2.6H_2O$ red-violet hygs.
$MgSO_4.7H_2O$ white	p-purple time 23hrs.	$MnSO_4.4H_2O$ pink hygs.	p-red pink	Na_2CO_3 white	p-purple time 23hrs.
$Na_2C_4H_4O_6.2H_2O$ white	p-blue--purple time 23hrs.	$NaI.2H_2O$ white hygs.	p_1-green p_2-black	$Na_2S_2O_3.7H_2O$ white hygs.	p-blue
NaSCN white hygs.	p- blue	$Na_2HAsO_4.12H_2O$ white	p-dk.violet time 23hrs.	$NaH_2PO_4.12H_2O$ white	p-purple time 24hrs.
$(NH_4)_2C_2O_4$ white	p-purple time 1min.	$(NH_4)_2CrO_4$ dk.yellow	p-black time 15min.	$(NH_4)_2CO_3$ white hygs.	p-green time 1min.
$(NH_4)_2C_4HO_4$ white	p-blue time 1hrs.	NH_4I dk.yellow hygs.	p-dk.green time 1min.	$(NH_4)_2SO_4$ white	p-pink time 18hrs.
$NiSO_4.6H_2O$ green	p-brown time 20hrs.	PbO orange	p_1-white p_2-red orange time 24hrs.	Pb_3O_4 red orange	p_1-white p_2-orange time 24hrs.
$SrCO_3$ white	p-black time 3min.	$Sr(OH)_2.8H_2O$ white	p-black time 30min.	TiO_2 white	p-purple time 18hrs.
$Ti.K_2-(C_2O_4)_3$ white	p-pink--purple time 20hrs.				

Table 5.1 (Continued)

R_2 \ R_1	$CoF_2.4H_2O$ pink	R_2 \ R_1	$CoF_2.4H_2O$ pink	R_2 \ R_1	$CoF_2.4H_2O$ pink
$CuCl_2.2H_2O$ green blue	p-brown time 18hrs.	$Hg.K.(CN)_3$ white	p-brown time 18hrs.	$Hg_2(NO_2)_2$ white hygs.	p-orange- -pink time 1hrs.
$KC_2H_3O_2$ white	p-blue- -purple time 1hrs.	KCN white	p_1-yellow $p_2$dk.brown time 20hrs.	KCNO white	p-blue time 20hrs.
$KHCO_3$ white	p-purple time 1hrs.	KF white hygs	$p_1$blue- -purple time 1hrs.	KI white hygs.	$p_1$red $p_2$yellow time 28hrs.
$MnSO_4.4H_2O$ pink hygs.	p-red pink	NaSCN white	p-blue time 20hrs.	$NaI.2H_2O$ white hygs.	p-red- -purple time 1hrs.
$(NH_4)_2CO_3$ white hygs.	p-purple time 15min.	$(NH_4)_2CrO_4$ dk.yellow	p-black time 30hrs.	NH_4I dk.yellow hygs.	p-dk.yellow time 1min.

R_2 \ R_1	$Co(NO_3)_2.6H_2O$ red hygs.	R_2 \ R_1	$Co(NO_3)_2.6H_2O$ red hygs.	R_2 \ R_1	$Co(NO_3)_2.6H_2O$ red hygs.
$Hg.K.(CN)_3$ white	p_1-brown p_2-gray time 24hrs.	KBr white	p-purple time 1hrs.	$KC_2H_3O_2$ white	$p_1$blue- -purple time 1hrs.
KCl white	p_1-blue- time 1hrs. p_2-purple. time 15hrs.	$K_2Cr_2O_7$ red-orange	p_1-black time 20hrs.	KCN white	p_1-brown p_2-green time 22hrs.

Table 5.1 (Continued)

R_2 \ R_1	$Co(NO_3)_2 \cdot 6H_2O$ red hygs.	R_2 \ R_1	$Co(NO_3)_2 \cdot 6H_2O$ red hygs.	R_2 \ R_1	$Co(NO_3)_2 \cdot 6H_2O$ red hygs.
KCNO white	p_1-navy blue p_2-purple time 1hrs.	$K_2C_2O_4 \cdot H_2O$ white	p-pink--purple time 1hrs.	KF white hygs.	p_1-blue--purple p_2-red time 1hrs.
$KHCO_3$ white	p-purple time 1hrs.	$Mg(BO_2)_2 \cdot 8H_2O$	p-pink--purple time 18hrs.	$MgCO_3$ white	p_1-dk.pink p_2-purple time 20hrs.
$MgC_2O_4 \cdot 2H_2O$ white	p-violet--pink time 18hrs.	$Mg_3(PO_4)_2 \cdot 4H_2O$ white	p-purple time 1hrs.	$MnCl_2 \cdot 4H_2O$ pink hygs.	p-red-pink
Na_2CO_3 white	p-purple time 18hrs.	$Na_2C_4H_4O_6 \cdot 2H_2O$ white	p-purple time 18hrs.	$Na_2HAsO_4 \cdot 12H_2O$ white	p-dk.violet time 18hrs.
$NaH_2PO_4 \cdot 12H_2O$ white	p-purple time 20hrs.	NaI white hygs.	p_1 brown p_2-orange time 1hrs	NaSCN white hygs.	p-navy blue
$NiSO_4 \cdot 6H_2O$ green	p-brown time 23hrs.	$SrCl_2 \cdot 6H_2O$ violet	p_1-dk.pink p_2-purple time 1hrs.	$SrCO_3$ white	p-dk.green time 1hrs.
$Sr(OH)_2 \cdot 8H_2O$ white	p_1-dk.green p_2-black p_3-brown time 1hrs.	ZnO white	p-purple time 23hrs.		

Table 5.1 (Continued)

R_2 \ R_1	Cr_2O_3 dk.red hygs.	R_2 \ R_1	Cr_2O_3 dk.red hygs.	R_2 \ R_1	Cr_2O_3 dk.red hygs.
$Al(C_2H_3O_2)_3$ white	p-black	As_2O_3 white	p-black	As_2S_3 orange	p-black
$CuCl_2.2H_2O$ blue green	p-dk.green	Cu_2Cl_2 yellow--green	p-black	$Cu(CN)_2$ yellow--gray	p-black time 1min.
$FeC_2O_4.2H_2O$ yellow	p-black	$Fe_2(C_2O_4)_3.5H_2O$ yellow--green	p-black	$FeCO_3$ brown-white	p-black
$Fe(NH_4)_2(SO_4)_2.6H_2O$ pale green blue	p-black	$Fe_3(PO_4)_2.8H_2O$ dk.green	p-black	KCN white	p-yellow--orange time 23hrs.
KCNO white	p-yellow time 22hrs.	$K_2C_2O_4.H_2O$ white	p-black time 1min.	$K_4Fe(CN)_6.3H_2O$ pale yellow	p-yellow time 23hrs.
$MgC_2O_4.2H_2O$ white	p-black	$MgC_4H_4O_6.4H_2O$ white	p-black	$MnCl_2.4H_2O$ rose hygs.	p-black
$MnCO_3$ brown	p-black	$MnC_2O_4.3H_2O$ pink	p-black	$Na_2C_2H_4O_6.2H_2O$ white	p-black
$NaH_2PO_4.12H_2O$ white	p-orange time 1hrs.	NaF white	p-orange -yellow time 23hrs.	NaSCN white hygs.	p-black

Table 5.1 (Continued)

R_2 \ R_1	Cr_2O_3 dk.red hygs.	R_2 \ R_1	Cr_2O_3 dk.red hygs.	R_2 \ R_1	Cr_2O_3 dk.red hygs.
$(NH_4)_2C_2O_4$ white	p-black	$(NH_4)_2$-$C_4H_4O_6$ white	p-black	NH_4I dk.yellow hygs.	p-black
PbC_2O_4 white	p-black	$PbC_4H_4O_6$ white	p-black	$Ti.K_2$-$(C_2O_4)_3$ white	p-black

R_2 \ R_1	$CuBr_2$ black	R_2 \ R_1	$CuBr_2$ black	R_2 \ R_1	$CuBr_2$ black
$CaSO_4$ white	p-brown time 22hrs.	Cu_2I_2 brown white	p-pale blue time 42hrs.	Cu_2O red	p-green time 24hrs.
$Mg(BO_2)_2 \cdot 8H_2O$ white	p-green--blue time 20hrs.	$MgC_4H_4O_6 \cdot 4H_2O$ white	p-dk.brown time 20hrs.	$Na_2HAsO_4 \cdot 12H_2O$ white	p_1-green p_2-blue time 20hrs.
$NaH_2PO_4 \cdot 12H_2O$ white	p-blue time 20hrs.	NaSCN white hygs.	p-yellow--brown	TiO_2 white	p-red--brown time 20hrs.
$Ti.K_2$-$(C_2O_4)_3$ white	p_1-red--brown p_2-black p_3-purple time 20hrs.	$Zn(CN)_2$ white	p-green--blue time 20hrs.	ZnO white	p-blue time 20hrs.

Table 5.1 (Continued)

R_2 \ R_1	$CuCl_2.2H_2O$ blue green	R_2 \ R_1	$CuCl_2.2H_2O$ blue green	R_2 \ R_1	$CuCl_2.2H_2O$ blue green
$Fe(NH_4)_2(SO_4)_2.6H_2O$ .pale green blue	p-dk.green time 10min.	$Hg.K.(CN)_3$ white	p-black time 20hrs.	$Hg_2(NO_2)_2$ white hygs.	p-blue time 46hrs.
HgO orange	p-green- -white time 20hrs.	Hg_2SO_4 white	p_1-blue p_2-green time 18hrs.	$K_2C_2O_4$ white	p_1-green p_2-blue time 20hrs.
$KC_2H_3O_2$ white	p-blue time 30min.	$K_2Cr_2O_7$ red-orange	p-green time 1hrs.	KF white hygs.	p_1-green- -white p_2-pale blue time 24hrs.
$K_3Fe(CN)_6$ dk.orange	p-brown time 20hrs.	$K_4Fe(CN)_6.3H_2O$ pale yellow	p-green time 30min.	$KHCO_3$ white	p-green time 1hrs.
$KMnO_4$ dk.purple	p-brown time 20hrs.	KNO_3 white	p-yellow time 1hrs.	K_2SO_4 white	p-green time 20hrs.
$LiC_7H_5O_3$ white	p-yellow -green time 16hrs.	$Mg(BO_2)_2.8H_2O$ white	p-yellow -green time 20hrs.	$MgCO_3$ white	p-green -blue time 20hrs.
$MgC_4H_4O_6.4H_2O$ white	p-yellow -green time 20hrs.	$Mg_3(PO_4)_2.4H_2O$ white	p-green -yellow time 20hrs.	$MgSO_4.7H_2O$ white	p_1-yellow- -green p_2-dk.green time 20hrs.
$MnCl_24H_2O$ pink hygs.	p-yellow	$MnC_2O_4.3H_2O$ pink	p-green time 40hrs.	$MnSO_4.4H_2O$ pink hygs.	p-green time 15min.

Table 5.1 (Continued)

R_2 \ R_1	$CuCl_2.2H_2O$ blue green	R_2 \ R_1	$CuCl_2.2H_2O$ blue green	R_2 \ R_1	$CuCl_2.2H_2O$ blue green
$Na_2C_2O_4$ white	p_1-green p_2-blue time 1hrs.	Na_2CO_3 white	p-dk.green time 18hrs.	$Na_2C_4H_4O_6.2H_2O$ white	p_1-green--yellow p_2-pale-blue time 20hrs.
NaF white	$p_1$green--yellow time 15hrs.	$NaI.2H_2O$ white hygs.	p_1-brown p_2-dk.green	$Na_2HASO_4.12H_2O$ white	$p_1$dk.green p_2-navy-blue time 20hrs.
$NaH_2PO_4.12H_2O$ white	p_1-pale-blue time 23hrs.	$Na_2SO_3.7H_2O$ white hygs.	p-black	NaSCN white hygs.	p-red brown
$(NH_4)_2CO_3$ white	p-blue	$(NH_4)_2CrO_4$ dk.yellow	p-red brown time 36hrs.	$(NH_4)_2C_2O_4$ white	p-blue time 20hrs.
NH_4F white hygs.	p-green time 1min.	NH_4I dk.yellow hygs.	p-black time 5min.	$NiSO_4.6H_2O$ green	p-green- time 20hrs.
PbI_2 yellow	p-dk.brown time 30min.	$Sr(BO_2)_2.5H_2O$ white	p-green time 20hrs.	$SrBr_2$ white hygs.	p-black time 5min.
$SrCO_3$ white	p-dk.green time 1hrs.	$Sr(NO_3)_2$ white	p-pale yellow--green time 1hrs.	$Sr(OH)_2.8H_2O$ white	p_1-dk.green p_2-blue $p_3$pale blue time 1hrs.
$SnCl_2.2H_2O$ white	p-yellow time 20hrs.	TiO_2 white	p-green time 20hrs.	$Ti.K_2(C_2O_4)_3$ white	p-green time 20hrs.

Table 5.1 (Continued)

R_2 \ R_1	Cu_2Cl_2 yellow-green	R_2 \ R_1	Cu_2Cl_2 yellow-green	R_2 \ R_1	Cu_2Cl_2 yellow-green
$CaCO_3$ white	p-dk.green time 23hrs.	$Ca_3(PO_4)_2$ white	p-dk.green time 22hrs.	KBr white	p-black time 22hrs.
KCNO white	p-blue time 20hrs.	$KC_2H_3O_2$ white	p-orange time 30min.	$Mg(BO_2)_2 \cdot 8H_2O$ white	p-yellow -green time 18hrs.
$MgC_2O_4 \cdot 2H_2O$ white	p-yellow- -green time 20hrs.	$MgCO_3$ white	p-yellow- -green time 20hrs.	$MgC_4H_4O_6 \cdot 4H_2O$ white	p-yellow- -green time 18hrs.
$MgSO_4 \cdot 7H_2O$ white	p_1-yellow- -green p_2-dk.green time 20hrs.	$NaC_2H_3O_2$ white hygs.	p-navy blue time 18hrs. time 18hrs.	$Na_2C_4H_4O_6 \cdot 2H_2O$ white	p-green- -yellow time 20hrs.
NaF white	P_1-yellow- -green p_2-yellow time 20hrs.	$Na_2HAsO_4 \cdot 12H_2O$ white	p-navy blue time 20hrs.	$NaH_2PO_4 \cdot 12H_2O$ white	p-green blue time 1hrs.
$NaI.2H_2O$ white hygs.	p-dk.gray time 30min.	NaSCN white hygs	p-red brown	$(NH_4)_2CrO_4$ dk.yellow	p-black time 20hrs.
NH_4I dk.yellow hygs.	p-green blue	$Ti.K_2(CN)_3$ white	p-yellow -green time 20hrs.	TiO_2 white	p-yellow -green time 20hrs.
$Zn(CN)_2$ white	p-black time 22hrs.	ZnO white	p-yellow- -green time 20hrs.		

Table 5.1 (Continued)

R_2 \ R_1	$Cu(CN)_2$ yellow grey	R_2 \ R_1	$Cu(CN)_2$ yellow grey	R_2 \ R_1	$Cu(CN)_2$ yellow grey
$HgCl_2$ white	p-blue time 20hrs.	$Hg.K.(CN)_3$ white	p-pale blue time 20hrs.	$Hg_2(NO_2)_2$ white hygs.	p-pale blue time 20hrs.
KCNO white	p-blue time 20hrs.	$KHCO_3$ white	p-pale blue time 30hrs.	$MnCl_2.4H_2O$ rose hygs.	p-green time 30hrs.
NaCl white	p-black	$NaI.2H_2O$ white hygs.	p-black	$Na_2SO_3.7H_2O$ white hygs.	p-white time 30hrs.
$SnCl_2.2H_2O$ white	p-green time 20hrs.	TiO_2 white	p-pale time 20hrs.		

R_2 \ R_1	$2CuCO_3.Cu(OH)_2$ pale blue-white	R_2 \ R_1	$2CuCO_3.Cu(OH)_2$ pale blue-white	R_2 \ R_1	$2CuCO_3.Cu(OH)_2$ pale blue-white
KBr white	p-black time 20hrs.	KCNO white	p-blue time 20hrs.	$NaH_2PO_4.12H_2O$ white	p-blue time 20hrs.

R_2 \ R_1	CuO black hygs.	R_2 \ R_1	CuO black hygs.	R_2 \ R_1	CuO black hygs.
$Hg_2(NO_2)_2$ white hygs.	p_1-blue p_2-yellow time 20hrs.	$NaH_2PO_4.12H_2O$ white	p-blue time 22hrs.	$SnCl_2.2H_2O$ white	p_1-green p_2-blue time 22hrs.

Table 5.1 (Continued)

R_2 \ R_1	$Cu(C_2H_3O_2)_2 \cdot 2H_2O$ navy blue
K_2CrO_4 yellow	p-black time 22hrs.
$Na_2C_4H_4O_6 \cdot 12H_2O$ white	p-blue time 22hrs.
$Na_2SO_3 \cdot 7H_2O$ white hygs.	p-yellow time 20hrs.
NH_4I yellow hygs.	p-black time 15min.

R_2 \ R_1	$Cu(C_2H_3O_2)_2 \cdot 2H_2O$ navy blue
$KC_2H_3O_2$ white	p-blue time 20hrs.
$NaI.2H_2O$ white	p_1-dk. -yellow p_2-white
NaSCN white hygs.	p_1-blue p_2-brown- -white
$SrBr_2$ white hygs.	p-black time 30min.

R_2 \ R_1	$Cu(C_2H_3O_2)_2 \cdot 2H_2O$ navy blue
KI white hygs.	p-dk.yellow NaH_2PO_4 time 30min.
$NaH_2PO_4 \cdot 12H_2O$ white	p-navy blue time 20hrs.
$(NH_4)_2CO_3$ white hygs.	p-blue time 15min.

R_2 \ R_1	$Cu(NO_3)_2 \cdot 6H_2O$ blue hygs.
Cu_2O red	p-green time 20hrs.
$MgC_2O_4 \cdot 2H_2O$ white	p-navy blue time 20hrs.
$Na_2HASO_4 \cdot 12H_2O$ white	p-blue time 20hrs.

R_2 \ R_1	$Cu(NO_3)_2 \cdot 6H_2O$ blue hygs.
$Mg(BC_2)_2 \cdot 8H_2O$ white	p-navy blue time 20hrs.
$MgSO_4 7H_2O$ white	p-green blue time 22hrs.
$NaH_2PO_4 \cdot 12H_2O$ white	p-blue time 20hrs.

R_2 \ R_1	$Cu(NO_3)_2 \cdot 6H_2O$ blue hygs.
$MgCO_3$ white	p-pale blue time 20hrs.
$Na_2C_4H_4O_6 \cdot 2H_2O$ white	p-blue time 20hrs.
NaSCN white hygs.	$p_1$dk.blue p_2-black

Table 5.1 (Continued)

R_2 \ R_1	Cu_2I_2 brown-white	R_2 \ R_1	Cu_2I_2 brown-white	R_2 \ R_1	Cu_2I_2 brown-white
$K_2C_2O_4$ white	p-blue time 42hrs.	KCN white	p-green time 18hrs.	KCNO white	p-green time 18hrs.
$KHCO_3$ white	p_1-blue p_2-green time 20hrs.	$MnSO_4.4H_2O$ pink hygs.	p-dk.grey time 22hrs.	Na_2CO_3 white	p-blue time 30hrs.

R_2 \ R_1	$CuSO_4.5H_2O$ blue	R_2 \ R_1	$CuSO_4.5H_2O$ blue	R_2 \ R_1	$CuSO_4.5H_2O$ blue
KBr white	p-black time 20hrs.	KCNO white	p-blue time 22hrs.	KI white hygs.	p-brown time 5min.
NaCl white	p-yellow--blue time 20hrs.	$NaI.2H_2O$ white hygs.	p-red brown	$NaH_2PO_4.12H_2O$ white	p-pale--blue time 18hrs.
NaSCN white hygs.	p-black time 5min.	$(NH_4)_2CO_3$ white hygs.	p-blue	$(NH_4)_2CrO_4$ dk.yellow	p-red brown time 36hrs.
NH_4I dk.yellow hygs.	p-brown	$SrCl_2.6H_2O$ white	p-green time 22hrs.		

Table 5.1 (Continued)

R_2 \ R_1	$CuSO_4$ blue-white	R_2 \ R_1	$CuSO_4$ blue-white	R_2 \ R_1	$CuSO_4$ blue-white
$Hg_2(NO_2)_2$ white	p-pale blue time 15min.	KCl white	p-green time 20hrs.	$KC_2H_3O_2$ white	p_1-green p_2-blue time 22hrs.
KCN white	p_1-yellow p_2-green p_3-gray time 24hrs.	KCNO white	p-green--blue time 22hrs.	KI white hygs.	p-dk.brown time 2min.
$MnCl_2.4H_2O$ pink hygs.	p-yellow	$NaI.2H_2O$ white hygs.	p_1-brown p_2-black	NaSCN white hygs.	p-black time 10min.
$Na_2SO_3.7H_2O$ white hygs.	p-yellow brown time 20hrs.	$(NH_4)_2CrO_4$ dk.yellow	p-dk. blue time 22hrs.	$(NH_4)_2CO_3$ white hygs.	p-blue-purple
NH_4F white hygs.	p-pale blue time 22hrs.	NH_4I dk.yellow hygs.	p-brown	$Sr(BO_2)_2.5H_2O$ white	p-dk.brown time 22hrs
$SrBr_2$ white hygs.	p-black	$SrCl_2.6H_2O$ white	p_1-green p_2-yellow--green time 22hrs.	$SnCl_2.2H_2O$ white	p-yellow time 20hrs.

R_2 \ R_1	Cu_2O black	R_2 \ R_1	Cu_2O black	R_2 \ R_1	Cu_2O black
$MgC_2O_4.2H_2O$ white	p-dk.green--white time 22hrs.	NH_4F white hygs.	p-dk.red time 18hrs.	$SnCl_2.2H_2O$ white	p-green time 20hrs.

Table 5.1 (Continued)

R_2 \ R_1	$Fe_2(C_2O_4)_3 \cdot 5H_2O$ yellow green	R_2 \ R_1	$Fe_2(C_2O_4)_3 \cdot 5H_2O$ yellow green	R_2 \ R_1	$Fe_2(C_2O_4)_3 \cdot 5H_2O$ yellow green
$Hg.K.(CN)_3$ white	p-brown time 22hrs.	KCl white	p_1-yellow p_2-brown time 22hrs.	KCN white	p_1-red brown p_2-white time 20hrs.
$KC_2H_3O_2$ white	p-brown time 1hrs.	KCNO white	p-red brown time 1hrs.	KF white hygs.	p_1-yellow- p_2-white time 1hrs.
KI white hygs.	p-brown time 30min.	$LiC_7H_5O_3$ white	p-black time 16hrs.	$MnCl_2.4H_2O$ rose hygs.	p-yellow time 22hrs.
NaCl white	p-yellow time 24hrs.	Na_2CO_3 white	p-dk. brown time 22hrs.	$NaC_2H_3O_2$ white	p-brown time 23hrs.
$NaH_2PO_4 \cdot 12H_2O$ white	p-white time 22hrs.	$NaI.2H_2O$ white hygs.	p-brown	$NaNO_3$ white	p-yellow time 18hrs.
$Na_2SO_3.7H_2O$ white hygs.	p-yellow time 20hrs.	$(NH_4)_2CO_3$ white hygs.	p-yellow. time 1min.	$(NH_4)_2CrO_4$ dk.yellow	p-brown time 20hrs.
NH_4I dk.yellow hygs.	p-black time 1min.	$SrBr_2$ white hygs.	p-red time 30min.	$SnCl_2.2H_2O$ white	p-yellow time 16hrs.

Table 5.1 (Continued)

R_2 \ R_1	$FeC_2O_4 \cdot 2H_2O$ yellow	R_2 \ R_1	$FeC_2O_4 \cdot 2H_2O$ yellow	R_2 \ R_1	$FeC_2O_4 \cdot 2H_2O$ yellow
$Hg.K.(CN)_3$ white	p-brown time 18hrs.	KCNO white	p-red time 16hrs.	KF white hygs.	p-black time 18hrs.

R_2 \ R_1	$Fe(NH_4)_2(SO_4)_2.6H_2O$ pale blue	R_2 \ R_1	$Fe(NH_4)_2(SO_4)_2.6H_2O$ pale blue	R_2 \ R_1	$Fe(NH_4)_2(SO_4)_2.6H_2O$ pale blue
$HgCl_2$ white	p-red brown time 24hrs.	$Hg_2(NO_2)_2$ white hygs.	p-brown time 16hrs.	KBr white	p-yellow time 20hrs.
KCl white	p-yellow time 22hrs.	KCN white	p_1-yellow p_2-green time 20hrs.	$KC_2H_3O_2$ white	p_1-black p_2-orange time 23hrs.
KCNO white	p-brown time 18hrs.	KF white hygs.	p-pale brown	$KHCO_3$ white	p-red time 24hrs.
KI white hygs.	p-yellow--orange time 20hrs.	$Mg(BO_2)_2 \cdot 8H_2O$ white	p-dk.yellow time 22hrs.	$MgCO_3$ white	p-yellow time20hrs.
$MnCl_2.4H_2O$ rose hygs.	p-yellow	Na_2CO_3 white	p-dk.brown time 20hrs.	$NaC_2H_3O_2$ white	p-brown time 23hrs.
$NaI.2H_2O$ white hygs.	p-yellow--brown time 22hrs.	$NaH_2PO_4 \cdot 12H_2O$ white	p_1-black p_2-white time 22hrs.	$NaNO_3$ white	p-orange time 24hrs.

Table 5.1 (Continued)

R_2 \ R_1	$Fe(NH_4)_2(SO_4)_2.6H_2O$ pale blue	R_2 \ R_1	$Fe(NH_4)_2(SO_4)_2.6H_2O$ pale blue	R_2 \ R_1	$Fe(NH_4)_2(SO_4)_2.6H_2O$ pale blue
$(NH_4)_2CrO_4$ dk.yellow	p-red brown time 32hrs.	$SrCl_2.6H_2O$ white	p-green--yellow time 23hrs.	$Sr(NO_3)_2.4H_2O$ white	p-dk.yellow time 20hrs.

R_2 \ R_1	$Fe_3(PO_4)_2.8H_2O$ white-blue	R_2 \ R_1	$Fe_3(PO_4)_2.8H_2O$ white-blue	R_2 \ R_1	$Fe_3(PO_4)_2.8H_2O$ white-blue
Cr_2O_3 dk.red hygs.	p-black	$Hg.K.(CN)_3$ white	p-red brown time 23hrs.	KCN white	p-yellow time 18hrs.
KCNO white	p-yellow--brown time 18hrs.	KF white hygs.	p-dk.brown time 1hrs.	$NaI.2H_2O$ white hygs.	p-yellow time 1hrs.

R_2 \ R_1	$FeSO_4.7H_2O$ green-white	R_2 \ R_1	$FeSO_4.7H_2O$ green-white	R_2 \ R_1	$FeSO_4.7H_2O$ green-white
KCl white	p-yellow time 18hrs.	KCN white	p_1-green p_2-white time 22hrs.	$KC_2H_3O_2$ white	p-brown time 1hrs.
KF white hygs.	p_1-black p_2-brown time 1hrs	$MnCl_2.4H_2O$ rose hygs.	p-yellow time 21hrs.	$NaH_2PO_4.12H_2O$ white	p-black time 22hrs.
$NaI.2H_2O$ white hygs.	p-yellow--brown time 18hrs.	$SnCl_2.2H_2O$ white	p-green time 16hrs.	$Zn(CN)_2$ white	p-white time 21hrs.

Table 5.1 (Continued)

R_2 \ R_1	$HgCl_2$ white	R_2 \ R_1	$HgCl_2$ white	R_2 \ R_1	$HgCl_2$ white
Ferric - Citrate brown hygs.	p-black time 24hrs.	$Hg.K.(CN)_3$ white	p-yellow time 20hrs.	HgO orange	p-dk.gray time 20hrs.
KCN white	p_1-brown p_2-green time 22hrs.	KCNO white	p-yellow time 20hrs.	K_2CrO_4 yellow	p-dk.yellow time 16hrs.
$KHCO_3$ white	p_1-yellow p_2-pink time 18hrs.	KF white hygs.	p_1-yellow p_2-orange	$K_4Fe(CN)_6 \cdot 3H_2O$ pale yellow	p-pale green time 18hrs.
KI white hygs.	p_1-orange p_2-dk.- time 1hrs.	$LiC_7H_5O_3$ white	p-black	$Mg(BO_2)_2 \cdot 8H_2O$ white	p-orange time 20hrs.
$MgCO_3.5H_2O$ white	p-orange -pink time 18hrs.	$MnCl_2.4H_2O$ rose hygs.	p-brown time 16hrs.	Na_2CO_3 white	p-dk.brown time 20hrs.
$Na_2HAsO_4 \cdot 12H_2O$ white	p-brown time 24hrs.	$NaI.2H_2O$ white hygs.	p-red orange time 1hrs.	$Na_2SO_3 \cdot 7H_2O$ white hygs.	p-dk.brown time 1hrs.
NH_4I dk.yellow hygs.	p-red orange	$PbHAsO_4$ white	p-orange yellow time 20hrs.	$SrCO_3$ white	p-brown- -white time 18hrs.
$SnCl_2.2H_2O$ white	p-dk.gray				

Table 5.1 (Continued)

R_2 \ R_1	HgI_2 red orange	R_2 \ R_1	HgI_2 red orange	R_2 \ R_1	HgI_2 red orange
KCN white	p-white time 1hrs	$K_4Fe(CN)_6 . 3H_2O$ pale yellow	p-brown time 18hrs.	Na_2CO_3 white	p-yellow
$NaI.2H_2O$ white hygs.	p-yellow time 1hrs.	$SnCl_2.2H_2O$ white hygs.	p-yellow time 20hrs.		

R_2 \ R_1	$Hg.K.(CN)_3$ white	R_2 \ R_1	$Hg.K.(CN)_3$ white	R_2 \ R_1	$Hg.K.(CN)_3$ white
As_2S_3 orange	p_1-dk.brown p_2-yellow time 16hrs.	$Hg_2(NO_2)_2$ white hygs.	p-gray time 24hrs.	Hg_2SO_4 white	p-black time 22hrs.
$K_2Cr_2O_7$ orange	p-yellow time 16hrs.	$MnC_2O_4 . 3H_2O$ pink	p-brown time 18hrs.	$NiCl_2.6H_2O$ green hygs.	p-blue -green time 16hrs.
$Ni(NO_3)_2 . 6H_2O$ green hygs.	p-blue- -green time 16hrs.	$SbCl_3$ white hygs.	p-blue time 60min.	Sb_2S_3 black	p-brown time 23hrs.

R_2 \ R_1	$Hg_2(NO_2)_2$ white hygs.	R_2 \ R_1	$Hg_2(NO_2)_2$ white hygs.	R_2 \ R_1	$Hg_2(NO_2)_2$ white hygs.
$Al(OH)_3$ white	p-yellow time 20hrs	CdI_2 white	p-red time 18hrs.	$CrCO_3$ blue-gray	p-black time 20hrs.

Table 5.1 (Continued)

R_2 \ R_1	$Hg_2(NO_2)_2$ white hygs.	R_2 \ R_1	$Hg_2(NO_2)_2$ white hygs.	R_2 \ R_1	$Hg_2(NO_2)_2$ white hygs.
Ferric-Citrate brown hygs.	p-black time 18hrs.	NH_4Cl white	p-white time 32hrs.	$(NH_4)_2CO_3$ white hygs.	p-grey
$(NH_4)_2CrO_4$ dk.yellow	p_1-orange p_2-black	$(NH_4)_2C_2O_4$ white	p-white time 32hrs.	$(NH_4)_2$-$C_4H_4O_6$ white	p-balck time 34hrs.
NH_4F white hygs.	p-black time 4Ohrs.	NH_4I white hygs.	p_1-brown p_2-orange	$(NH_4)_2SO_4$ white	p-white time 42hrs.

R_2 \ R_1	HgO orange	R_2 \ R_1	HgO orange	R_2 \ R_1	HgO orange
KI white hygs.	p-orange--yellow time 10min.	$MnCl_2.4H_2O$ rose hygs.	p-brown time 18hrs.	$NaI.2H_2O$ white hygs.	p-orange time 23hrs.
$Na_2SO_3.7H_2O$ white hygs.	p_1-black p_2-orange time 22hrs.	NH_4I dk.yellow hygs.	p-violet time 20hrs.	$NiCl_2.6H_2O$ green hygs.	p-black time 18hrs.
$SrCl_2.6H_2O$ white	p-brown--white time 18hrs.	$SnCl_2.2H_2O$ white	p-dk.gray time 22hrs.		

Table 5.1 (Continued)

R_2 \ R_1	Hg_2SO_4 white
KCN white	p-black time 1hrs.
KF white hygs.	p-black time 1hrs.
$Na_2HAsO_4 \cdot 12H_2O$ white	p-brown time 16hrs.
NaSCN white hygs.	p-black
$(NH_4)_2C_2O_4$ white	p-black time 1hrs.
NH_4I dk.yellow hygs.	p-black time 1hrs.
$Ni(NO_3)_2 \cdot 6H_2O$ green hygs.	p-green--blue time 1hrs.
$Zn(NO_3)_2$ white hygs.	p-pale--brown time 1hrs.

R_2 \ R_1	Hg_2SO_4 white
$KC_2H_3O_2$ white	p-brown time 1hrs.
$KHCO_3$ white	p-black time 18hrs.
NaI.$2H_2O$ white hygs.	p_1-black p_2-yellow p_3-red--orange time 10min.
$(NH_4)_2CO_3$ white hygs.	p-black time 5min.
$(NH_4)_2$--$C_4H_4O_6$ white	p-black time 1hrs.
$(NH_4)_2SO_4$ white	p-black time 1hrs.
$SrCl_2 \cdot 6H_2O$ white	p-dk.gray time 20hrs.

R_2 \ R_1	Hg_2SO_4 white
KCNO white	p-black time 1hrs.
KI white	p_1-dk.gray p_2-yellow p_3-green time 10min.
$Na_2SO_3 \cdot 7H_2O$ white hygs.	p-black time 1hrs.
$(NH_4)_2CrO_4$ dk.yellow	p-black time 1hrs.
NH_4F white hygs.	p-black time 10min.
$NiCl_2 \cdot 6H_2O$ green hygs.	p-green--blue time 1hrs.
$SnCl_2 \cdot 2H_2O$ white	p-black time 1hrs.

Table 5.1 (Continued)

R_2 \ R_1	K_2CrO_4 yellow	R_2 \ R_1	K_2CrO_4 yellow	R_2 \ R_1	K_2CrO_4 yellow
$MnCl_2.4H_2O$ rose hygs.	p-dk.brown	Na_2CO_3 white	p-orange time 30hrs.	$NaH_2PO_4.12H_2O$ white	p_1-red--orange p_2-yellow time 1hrs.
NH_4F white hygs.	p-orange time 1hrs	$NiCl_2.6H_2O$ green	p-red brown time 1hrs.	$Ni(NO_3)_2$ $6H_2O$ green hygs.	p-red brown time 1hrs.
$SrCl_2.6H_2O$ white	p-dk.yellow time 20hrs.	$SnCl_2.2H_2O$ white	p_1-dk.yellow p_2-brown p_3-green time 1hrs.	$ZnCl_2$ white hygs	p-orange time 1hrs.

R_2 \ R_1	$K_2Cr_2O_7$ red orange	R_2 \ R_1	$K_2Cr_2O_7$ red orange	R_2 \ R_1	$K_2Cr_2O_7$ red orange
$BaBr_2$ white hygs.	p-brown time 20hrs.	KCN white	p-yellow time 20hrs.	$KC_2H_3O_2$ white	p-yellow time 20hrs.
KF white hygs.	p-yellow time 18hrs.	$MnCl_2.4H_2O$ rose hygs.	p-red brown	$MnSO_4.4H_2O$ pink hygs.	p-yellow -white time 20hrs.
NaCl white	p-yellow time 20hrs.	$NaH_2PO_4.12H_2O$ white	p-yellow time 20hrs.	$Na_2C_4H_4O_6.2H_2O$ white	p-red brown time 20hrs.
$NaNO_3$ white	p-yellow time 20hrs.	NaSCN white hygs.	p_1-yellow p_2-brown	$NiCl_2.6H_2O$ green hygs.	p-yellow time 18hrs.

Table 5.1 (Continued)

R_2 \ R_1	KCN white	R_2 \ R_1	KCN white	R_2 \ R_1	KCN white
$Cr_2(SO_4)_3$ dk.green hygs.	p-dk.brown time 90min.	$K_3Fe(CN)_6$ dk.orange	p-yellow--green time 20hrs.	$KMnO_4$ dk.purple	p_1-yellow p_2-brown time 20hrs.
$MgSO_4.7H_2O$ white	p_1-black p_2-brown time 20hrs.	$MnCO_3$ brown	p-red time 21hrs.	$MnCl_2.4H_2O$ rose hygs.	p-black time 21hrs.
$MnC_2O_4.3H_2O$ pink	p_1-brown p_2-orange--brown time 10hrs.	$MnSO_4.4H_2O$ pink hygs.	p_1-red p_2-black time 18hrs.	$NaH_2PO_4.12H_2O$ white	p-brown time 20hrs.
$NiCO_3$ green--white	p-dk.yellow time 18hrs.	NiO dk.green	p-dk.yellow time 18hrs.	$NiCl_2.6H_2O$ green hygs.	p_1-yellow p_2-pale blue time 18hrs.
$Ni(NO_3)_2.6H_2O$ green hygs.	p_1-yellow p_2-pale blue time 20hrs.	$NiSO_4.6H_2O$ green	p_1-yellow p_2-pale -blue time 10min.	$Pb(NO_3)_2$ white	p-brown time 18hrs.

R_2 \ R_1	KCNO white	R_2 \ R_1	KCNO white	R_2 \ R_1	KCNO white
$KMnO_4$ dk.purple	p-yellow time 18hrs.	$MnC_2O_4.3H_2O$ $3H_2O$ pink	p_1-yellow p_2-brown time 1hrs.	NH_4I dk.yellow hygs.	p-red brown time 1hrs.
$NiSO_4.6H_2O$ green	p-yellow--green time 16hrs.	$SnCl_2.2H_2O$ white	p-black time 20hrs.		

Table 5.1 (Continued)

R_2 \ R_1	KF white hygs.	R_2 \ R_1	KF white hygs.	R_2 \ R_1	KF white hygs.
$(NH_4)_2CrO_4$ dk.yellow	p_1-yellow p_2-orange time 1hrs.	$NiCl_2.6H_2O$ green hygs.	p-yellow time 1hrs.	$Ni(NO_3)_2.6H_2O$ green hygs.	p-yellow time 1hrs. time 1hrs.
$NiSO_4.6H_2O$ green	p-pale yellow time 24hrs.	PbI_2 yellow	p-yellow -white time 20hrs.		

R_2 \ R_1	$K_3Fe(CN)_6$ red	R_2 \ R_1	$K_3Fe(CN)_6$ red	R_2 \ R_1	$K_3Fe(CN)_6$ red
$Cr_2(SO_4)_3.18h_2O$ dk.green	p-brown time 90min.	KI white hygs.	p_1-black p_2-brown time 18hrs.	$MnCl_2.4H_2O$ rose hygs.	p-red brown time 18hrs.
NaCl white	p-yellow time 21hrs.	Na_2CO_3 white	p-yellow time 21hrs.	$NaI.2H_2O$ white hygs.	p-yellow
NaSCN white hygs.	p_1-dk.green p_2-yellow- -orange time 20hrs.	$(NH_4)_2CO_3$ white hygs.	p-yellow time 20hrs.	NH_4I dk.yellow hygs.	p-brown time 1hrs.
$NiCl_2.6H_2O$ green hygs.	p-brown time 20hrs.	$SrCl_2.6H_2O$ white	p-green- -yellow time 18hrs.	$Sr(NO_3)_2.4H_2O$ white hygs.	p-yellow time 21hrs.

Table 5.1 (Continued)

R_2 \ R_1	$K_4Fe(CN)_6 \cdot 3H_2O$ pale yellow	R_2 \ R_1	$K_4Fe(CN)_6 \cdot 3H_2O$ pale yellow	R_2 \ R_1	$K_4Fe(CN)_6 \cdot 3H_2O$ pale yellow
$MnCl_2.4H_2O$ rose hygs.	p-yellow time 21hrs.	NaSCN white hygs.	p-white time 24hrs.	$SnCl_2.2H_2O$ white	p-green blue time 21hrs.

R_2 \ R_1	$KHCO_3$ white	R_2 \ R_1	$KHCO_3$ white	R_2 \ R_1	$KHCO_3$ white
$CrCl_3.6H_2O$ dk.green hygs.	p-blue -green	$FeC_2O_4 \cdot 2H_2O$ yellow	p-red brown time 20hrs.	$SnCl_2.2H_2O$ white	p-dk.gray time 1hrs.

R_2 \ R_1	KI white	R_2 \ R_1	KI white	R_2 \ R_1	KI white
$FeCO_3$ brown- -white	p-dk.purple time 18hrs.	$MnCl_2.4H_2O$ rose hygs.	p-dk.yellow time 40min.	$MnC_2O_4 \cdot 3H_2O$ pink	p-brown time 20hrs.
$MnSO_4.4H_2O$ pink hygs.	p_1-brown p_2-yellow time 21hrs.	$Pb(BO_2)_2 \cdot 2H_2O$ white	p-yellow time 23hrs.	$PbCl_2$ white	p-yellow time 1hrs.
$Pb(NO_3)_2$ white	p-yellow time 1hrs.	$SbCl_3$ white	p_1-red p_2-orange time 1hrs.	$Sr(BO_2)_2 \cdot 5H_2O$ white	p-brown -white time 21hrs.
$SnCl_2.2H_2O$ white	p-orange time 1hrs.	$Ti.K_2(C_2O_4)_3$ white	p-yellow time 24hrs.		

Table 5.1 (Continued)

R_2 \ R_1	K_2SO_4 white	R_2 \ R_1	K_2SO_4 white	R_2 \ R_1	K_2SO_4 white
NaSCN white hygs.	p-pale blue time 1hrs.	NH_4I yellow hygs.	p-dk.yellow time 20hrs.	$NiCl_2.6H_2O$ green hygs.	p-green yellow time 18hrs.

R_2 \ R_1	$MgSO_4.7H_2O$ white	R_2 \ R_1	$MgSO_4.7H_2O$ white		
$Cd(C_2H_3O_2)_2.2H_2O$ white	p-brown--white time 30hrs.	PbI_2 dk.yellow	p-red brown time20hrs.		

R_2 \ R_1	$MnCl_2.4H_2O$ rose hygs.	R_2 \ R_1	$MnCl_2.4H_2O$ rose hygs.	R_2 \ R_1	$MnCl_2.4H_2O$ rose hygs.
$BaCO_3$ white	p-brown time 1hrs.	KBr white	p-pale -brown time 18hrs.	Na_2CO_3 white	p-pale -brown time 22hrs.
$NaI.2H_2O$ white hygs.	p-yellow time 1hrs.	$(NH_4)_2CrO_4$ dk.yellow	p-black time 1hrs.	NH_4I dk.yellow hygs.	p-yellow time 1hrs.
$SrCO_3$ white	p-brown -white time 1hrs.	$Sr(OH)_2.8H_2O$ white	p-dk.brown time 1hrs.	ZnO white	p-brown -white time 24hrs.

Table 5.1 (Continued)

R_2 \ R_1	$MnCO_3$ brown	R_2 \ R_1	$MnCO_3$ brown	R_2 \ R_1	$MnCO_3$ brown
$CaCl_2.2H_2O$ white	p-dk.brown time	NaSCN white hygs.	p-black	NH_4I dk.yellow hygs.	p-red time 24hrs.
$SnCl_2.2H_2O$ white	p-black	$SrCl_2.6H_2O$ white	p-black time 20hrs.		

R_2 \ R_1	$MnC_2O_4.3H_2O$ pink hygs.	R_2 \ R_1	$MnC_2O_4.3H_2O$ pink hygs.	R_2 \ R_1	$MnC_2O_4.3H_2O$ pink hygs.
Na_2CO_3 white	p-brown time 21hrs.	$Na_2SO_3.7H_2O$ white hygs.	p_1-grey p_2-yellow time 24hrs.	$Sr(OH)_2.8H_2O$ white	p-dk.brown time 1hrs.

R_2 \ R_1	$MnSO_4.4H_2O$ pink	R_2 \ R_1	$MnSO_4.4H_2O$ pink	R_2 \ R_1	$MnSO_4.4H_2O$ pink
$NaI.2H_2O$ white hygs.	p-dk.yellow time 1hrs.	$(NH_4)_2CO_3$ white	p_1-brown p_2-gray	$(NH_4)_2C_2O_4$ white	p-black
NH_4I dk.yellow hygs.	p-orange -yellow	$SrCO_3$ white	p-dk.brown time 1hrs.	$Sr(OH)_2.8H_2O$ white	p-dk.brown time 24hrs.
$Zn(CN)_2$ white	p-brown -white time 32hrs.				

Table 5.1 (Continued)

R_2 \ R_1	$Na_2C_4H_4O_6.2H_2O$ white	R_2 \ R_1	$Na_2C_4H_4O_6.2H_2O$ white	R_2 \ R_1	$Na_2C_4H_4O_6.2H_2O$ white
$(NH_4)_2CrO_4$ dk.yellow	p-black time 24hrs.	$NiCl_2 6H_2O$ green hygs.	p-yellow--green time 20hrs.	$Ni(NO_3)_2.6H_2O$ green hygs.	p-yellow--green time 20hrs.

R_2 \ R_1	$NaI.2H_2O$ white hygs.	R_2 \ R_1	$NaI.2H_2O$ white hygs.	R_2 \ R_1	$NaI.2H_2O$ white hygs.
$KMnO_4$ dk.purple	p-yellow	$(NH_4)_2CrO_4$ dk.yellow	p_1-dk. -yellow p_2-black time 1hrs.	NH_4F white hygs.	p-orange -yellow time 20hrs.
$Pb(BO_2)_2.2H_2O$ white	p-yellow time 24hrs.	$PbCl_2$ white	p-yellow timw 1hrs.	$Pb(NO_3)_2$ white	p-yellow time 1hrs.
$SbCl_3$ white	p-orange time 1hrs.	$SnCl_2.2H_2O$ white	p_1-red--orange p_2-yellow		

R_2 \ R_1	$Na_2S_2O_3.7H_2O$ white hygs.	R_2 \ R_1	$Na_2S_2O_3.7H_2O$ white hygs.	R_2 \ R_1	$Na_2S_2O_3.7H_2O$ white hygs.
$CdCl_2$ white hygs.	p-yellow time 21hrs.	Cu_2I_2 brown-white	p-dk.brown time 30hrs.	$NiSO_4.6H_2O$ green	p-black time 1hrs.
$Pb(BO_2)_2.2H_2O$ white	p-gray time 20hrs.	$Pb(NO_3)_2$ white	p-gray time 20hrs.	$SnCl_2.2H_2O$ white	p-black time 30hrs

Table 5.1 (Continued)

R_2 \ R_1	NaSCN white hygs.	R_2 \ R_1	NaSCN white hygs.	R_2 \ R_1	NaSCN white hygs.
$Bi_2O_2CO_3 \cdot H_2O$	p-dk.yellow	CaF_2 white	p-pale -brown time 1hrs.	$Cr(NO_3)_3 \cdot 9H_2O$ green hygs.	p-black
$CrCl_3.6H_2O$ green hygs.	p-red- -violet time 20hrs.	$CoSO_4$ red-white	p-blue	$NiCl_2.6H_2O$ green hygs.	p-black
$Ni(NO_3)_2 \cdot 6H_2O$ green hygs.	p-black	$NiSO_4.6H_2O$ green	p-black	$Pb(C_2H_3O_2)_3 \cdot 3H_2O$ white	p-red- -orange time 20hrs.
$SbCl_3$ white	p-orange -yellow	$Ti.K_2(C_2O_4)_3$ white	p-yellow time 1hrs.	$FeSO_4.7H_2O$ green-white	p-red brown
$FeC_2O_4 \cdot 2H_2O$ yellow	p-red brown	$Fe_2(C_2O_4)_3 \cdot 5H_2O$ yellow- -green	p-red brown	$Fe_3(PO_4)_2 \cdot 7H_2O$ dk.green	p-red brown
$FeCO_3$ brown- -white	p-red brown	$Fe(NH_4)_2(SO_4)_2.6H_2O$	p-red brown	$Fe(NO_3)_3 \cdot 3H_2O$ yellow hygs.	p-red brown

R_2 \ R_1	$(NH_4)_2CO_3$ white hygs.	R_2 \ R_1	$(NH_4)_2CO_3$ white hygs.	R_2 \ R_1	$(NH_4)_2CO_3$ white hygs.
$CoSO_4.7H_2O$ red-white	p-black time 24hrs.	$SnCl_2.2H_2O$ white	p-brown time 23hrs.	PbI_2 yellow	p-brown time 20hrs.

Table 5.1 (Continued)

R_2 \ R_1	NaSCN white hygs.	R_2 \ R_1	NaSCN white hygs.	R_2 \ R_1	NaSCN white hygs.
$Bi_2O_2CO_3 \cdot H_2O$	p-dk.yellow	CaF_2 white	p-pale -brown time 1hrs.	$Cr(NO_3)_3 \cdot 9H_2O$ green hygs.	p-black
$CrCl_3 \cdot 6H_2O$ green hygs.	p-red- -violet time 20hrs.	$CoSO_4$ red-white	p-blue	$NiCl_2 \cdot 6H_2O$ green hygs.	p-black
$Ni(NO_3)_2 \cdot 6H_2O$ green hygs.	p-black	$NiSO_4 \cdot 6H_2O$ green	p-black	$Pb(C_2H_3O_2)_3 \cdot 3H_2O$ white	p-red- -orange time 20hrs.
$SbCl_3$ white	p-orange -yellow	$Ti.K_2(C_2O_4)_3$ white	p-yellow time 1hrs.	$FeSO_4 \cdot 7H_2O$ green-white	p-red brown
$FeC_2O_4 \cdot 2H_2O$ yellow	p-red brown	$Fe_2(C_2O_4)_3 \cdot 5H_2O$ yellow- -green	p-red brown	$Fe_3(PO_4)_2 \cdot 7H_2O$ dk.green	p-red brown
$FeCO_3$ brown- -white	p-red brown	$Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$	p-red brown	$Fe(NO_3)_3 \cdot 3H_2O$ yellow hygs.	p-red brown

R_2 \ R_1	$(NH_4)_2CO_3$ white hygs.	R_2 \ R_1	$(NH_4)_2CO_3$ white hygs.	R_2 \ R_1	$(NH_4)_2CO_3$ white hygs.
$CoSO_4 \cdot 7H_2O$ red-white	p-black time 24hrs.	$SnCl_2 \cdot 2H_2O$ white	p-brown time 23hrs.	PbI_2 yellow	p-brown time 20hrs.

Table 5.1 (Continued)

R_2 \ R_1	$(NH_4)_2CrO_4$ dk. yellow	R_2 \ R_1	$(NH_4)_2CrO_4$ dk. yellow	R_2 \ R_1	$(NH_4)_2CrO_4$ dk. yellow
$BaBr_2.2H_2O$ white hygs.	p-yellow time 24hrs.	$Ba(NO_3)_2$ white	p-orange--yellow time 36hrs.	$KC_2H_3O_2$ white	p-orange time 42hrs.
NaCl white	p-yellow time 18hrs.	Na_2CO_3 white	p-yellow time 24hrs.	$Sr(NO_3)_2.4H_2O$ white	p-yellow time 24hrs.

R_2 \ R_1	NH_4I dk. yellow hygs.	R_2 \ R_1	NH_4I dk. yellow hygs.	R_2 \ R_1	NH_4I dk. yellow hygs.
$Ca(OH)_2$ white	p-gray time 5min.	$CdSO_4$ white	p-orange--white time 18hrs.	$CrCO_3$ blue-gray	p-black time 20hrs.
$Fe_3(PO_4)_2.7H_2O$ dk.green	p-brown time 24hrs.	$FeCO_3$ brown--white	p-brown	$SrCO_3$ white	p_1-black p_2-yellow--white time 1hrs.
$SnCl_2.2H_2O$ white	p_1-yellow p_2-orange time 1hrs.	ZnO white	p-yellow time 30hrs.		

R_2 \ R_1	PbI_2 yellow	R_2 \ R_1	PbI_2 yellow	R_2 \ R_1	PbI_2 yellow
$Fe(NO_3)_3.H_2O$ yellow hygs.	p-black	$MgC_2O_4.2H_2O$ white	p-yellow time 18hrs.	$SnCl_2.2H_2O$ white	p-black time 22hrs.

Table 5.1 (Continued)

R_2 \ R_1	$NiCl_2.6H_2O$ green hygs.	R_2 \ R_1	$NiCl_2.6H_2O$ green hygs.	R_2 \ R_1	$NiCl_26H_2O$ green hygs.
$CoCO_3$ rose	p-black time 1hrs.	Hg_2S red	p-red time 40hrs.	KBr white	p-yellow time 1hrs.
KCl. white	p-green time 20hrs.	$K_2C_2O_4$ white	p-green- -white time 20hrs.	$Sr(OH)_2.$ $8H_2O$ white	p-dk.green time 18hrs.

R_2 \ R_1	$Ni(NO_3)_2.$ $6H_2O$ green hygs.	R_2 \ R_1	$Ni(NO_3)_2.$ $6H_2O$ green hygs.	R_2 \ R_1	$Ni(NO_3)_2.$ $6H_2O$ green hygs.
KCl white	p-green- -yellow time 1hrs.	$K_2C_2O_4$ white	p-green- -white time 21hrs.	K_2SO_4 white	p-blue time 21hrs.
$SrCl_2.6H_2O$ white	p-dk.green time 30hrs.	$Sr(OH)_2.$ $8H_2O$ white	p-dk.green time 20hrs.	$Ti.K_2-$ $(C_2O_4)_3$ white	p-blue- -green time 18hrs.

R_2 \ R_1	TiO_2 white	R_2 \ R_1	$Ti.K_2-$ $(C_2O_4)_3$ white	R_2 \ R_1	$Zn(CN)_2$ white
Cu_2I_2 brown- -white	p-green time 20hrs.	CaI_2 yellow- -brown hygs.	p-dk.- -yellow time 24hrs.	$CuCl_2.2H_2O$ blue green	p-green time 22hrs.
$Cu(NO_3)_2.$ $3H_2O$ navy blue hygs.	p-pale blue white time 23hrs.	$LiC_7H_5O_3$ white	p-yellow time 16hrs.		

Table 5.1 (Continued)

R_2 \ R_1	$SnCl_2.2H_2O$ white	R_2 \ R_1	$SnCl_2.2H_2O$ white	R_2 \ R_1	$SnCl_2.2H_2O$ white
$BaCl_2.2H_2O$ white	p-yellow--orange time 24hrs.	BaS pale gray	p-dk.red--brown time 5min.	$Bi_2O_2CO_3.$ H_2O white	p-gray time 22hrs
$Ca(OH)_2$ white	p_1-brown--white p_2-yellow time 23hrs.	$2CuCO_3.$ $Cu(OH)_2$ pale-blue--white	p_1-dk. -green p_2-yellow--green time 23hrs.	$Fe(NH_4)_2-$ $(SO_4)_2.6H_2O$ pale blue	p_1-blue p_2-green time 16hrs.
$Hg.K.(CN)_3$ white	p-gray time 3min.	$K_2Cr_2O_7$ orange	p-dk.green time 1hrs.	KCN white	p_1-yellow p_2-gray time 20hrs.
$KC_2H_3O_2$ white	p_1-yellow p_2-red time 23hrs.	$(NH_4)_2CrO_4$ dk.yellow	p_1-green p_2-yellow--blue time 22hrs.	$Mg(BO_2)_2.$ $8H_2O$ white	p-orange time 21hrs.
Na_2CO_3 white	p-brown time 20hrs.	$SrCO_3$ white	p-brown--white time 1hrs.	$Sr(OH)_2.$ $8H_2O$ white	p_1-yellow p_2-black time 1hrs.
ZnO white	p-yellow--brown time 16hrs.	TiO white	p-yellow time 22hrs.		

R_2 \ R_1	$SbCl_3$ white hygs.	R_2 \ R_1	$SbCl_3$ white hygs.	R_2 \ R_1	$SbCl_3$ white hygs.
$Al(NO_3)_3.$ $9H_2O$ white hygs.	p-yellow time 5min.	$SrCO_3$ white	p-pale--yellow time 1hrs.	$Sr(NO_3)_2.$ $4H_2O$ white	p_1-yellow p_2-black time 1hrs

Table 5.1 (Continued)

R_2 \ R_1	PbO orange	R_2 \ R_1	$SrCl_2.6H_2O$ white	R_2 \ R_1	$Sr(NO_3)_2.4H_2O$ white
$MgC_4H_4O_6.4H_2O$ white	p-dk.grey time 23hrs.	$CoF_2.4H_2O$ red	p_1-blue--purple p_2-purple p_3-violet time 24hrs.	$K_2Cr_2O_7$ red-orange	p-yellow time 20hrs

R_2 \ R_1	$Zn(NO_3)_2$ white				
K_2CrO_4 yellow	p_1-yellow time 1hrs. p_2-orange time 20hrs.				

R_2 \ R_1	ZnO white	R_2 \ R_1	ZnO white	R_2 \ R_1	ZnO white
Cr_2O_3 deep red hygs.	p_1-orange--yellow p_2-brown time 18hrs.	$CuCl_2.2H_2O$ blue green	p-dk.green time 18hrs.	$FeSO_4.7H_2O$ green-white	p-white time 18hrs.
$Ti.K_2(C_2O_4)_3$ white	p-yellow time 20hrs.				

The coloured observation period of 816 reactions lasted about two days. These were divided to be 131 instantaneous reaction (16%), three hours appearance 196 reactions (24%), one-day appearance 463 reactions (57%) and two-days 24 reactions (3%). The different colour products of 816 reactions could be classified into 688 one-product reactions (84%), 126 two-products reaction (15%), and 1% or 8 reactions for more than two products.

The number of colour products, which were produced in each pair of reactions, reported above was observed during work-time only, so any change that had appeared when the reaction were left overnight could be unable to inform. It was a pity for uncertain results which was unavoidable.

The process of ring method which was used to select reactions was limited by the rate of diffusion (diffusion sphere). The effect of long range unnoticed time and the rate limitation might decrease the number of study product. It was the continuity diffusion through solid might cause the change of intermediate product to another ones without notice which the limitation of rate in ring method might inhibit the occurrence of further products. For this reason, the whole lot of colour products could be observed if suitable experimental method were developed. The variation of temperature and moisture during a day often affected the rate of reactions and also the number of product.

5.2 Rate of growth of product.

The result shown in the following Tables could represent the whole solid-solid reaction of this present work.

$$NiCl_2.6H_2O + (NH_4)_2C_2O_4$$

$NiCl_2.6H_2O$ - green

$(NH_4)_2C_2O_4$ - white

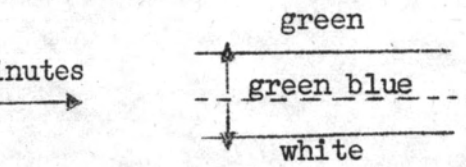


Table 5.2 Result of growth rate of solid reaction

$NiCl_2.6H_2O + (NH_4)_2C_2O_4$

Time	Thickness of		
	$NiCl_2$ green (cm)	$(NH_4)_2C_2O_4$ white (cm)	product green-blue (cm)
3 minutes	1.50	1.50	line
1 day	<1.50	<1.50	0.10
5 days	1.20	1.20	0.60
30 days	1.10	1.10	0.80

$$KF + (NH_4)_2CrO_4$$

KF - white

$(NH_4)_2CrO_4$ - dark yellow

10 minutes →

white

lemon yellow

dark yellow

Table 5.3 Result of growth rate of solid reaction $KF + (NH_4)_2CrO_4$

Time	Thickness		
	KF - white (cm)	$(NH_4)_2CrO_4$ - dark yellow (cm)	lemon yellow product
0	1.50	1.50	-
10 minutes	1.50	<1.50	line
3 hours	1.50	0.90	0.60
1 days	<1.50	0.60	0.90

$KCNO + CoCl_2.6H_2O$

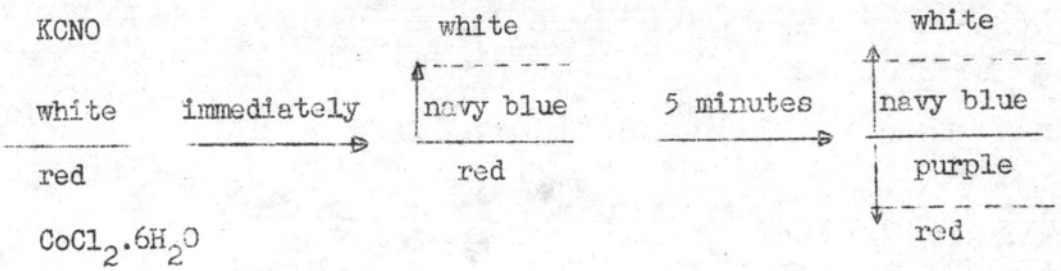


Table 5.4 Result of growth rate of solid reaction

$KCNO + CoCl_2.6H_2O$

Time	Thickness			
	$CoCl_2.6H_2O$-red (cm)	KCNO-white (cm)	navy blue (cm)	purple (cm)
immediately	1.50	< 1.50	line	-
5 minutes	< 1.50	1.40	0.10	line
15 minutes	1.20	1.30	0.20	0.30
1 days	0.90	1.20	0.30	0.60
10 days	0.80	1.10	0.40	0.70
30 days	0.70	1.00	0.50	0.80

$$K_4Fe(CN)_6.3H_2O + CuCl_2.2H_2O$$

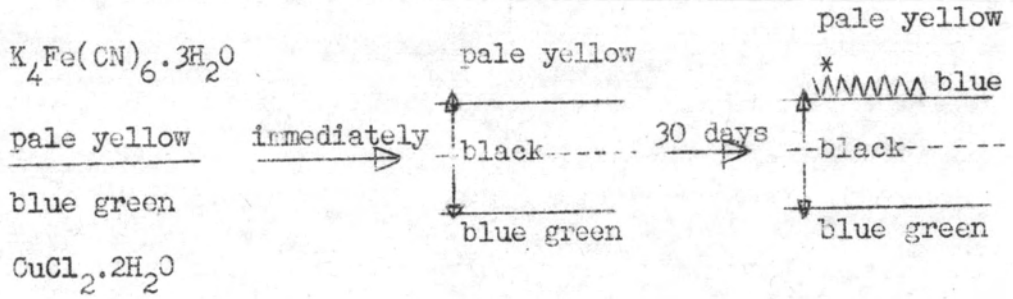


Table 5.5 Result of growth rate of solid reaction

$K_4Fe(CN)_6.3H_2O + CuCl_2.2H_2O$

Time	Thickness			
	$K_4Fe(CN)_6.3H_2O$ pale yellow (cm)	$CuCl_2.2H_2O$ blue green (cm)	black product (cm)	blue product (cm)
immediately	$<$1.50	$<$1.50	line	-
5 days	1.40	1.30	0.30	-
30 days	1.30	1.10	0.60	line
60 days	1.20	1.00	0.70	0.10
90 days	$<$1.20	1.00	0.70	0.15

* ∧∧∧∧ - line

$NiSO_4.6H_2O$ + NaSCN

green

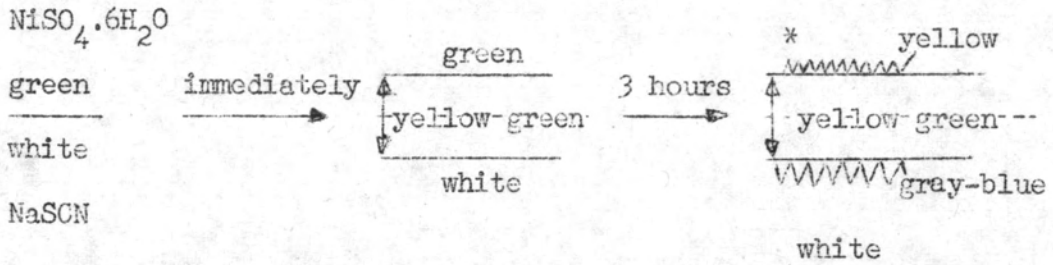


Table 5.6 Result of growth rate of solid reaction

$NiSO_4.6H_2O$ + NaSCN

Time	Thickness				
	$NiSO_4.6H_2O$ green (cm)	NaSCN white (cm)	yellow green product (cm)	yellow product (cm)	gray-blue product (cm)
immediately	1.50	1.50	line	-	-
3 hours	1.40	1.20	0.30	line	line
3 days	1.20	0.70	0.50	line	0.20
30 days	1.20	0.50	0.50	line	0.30

* ~~~~~~~~~~ thin line

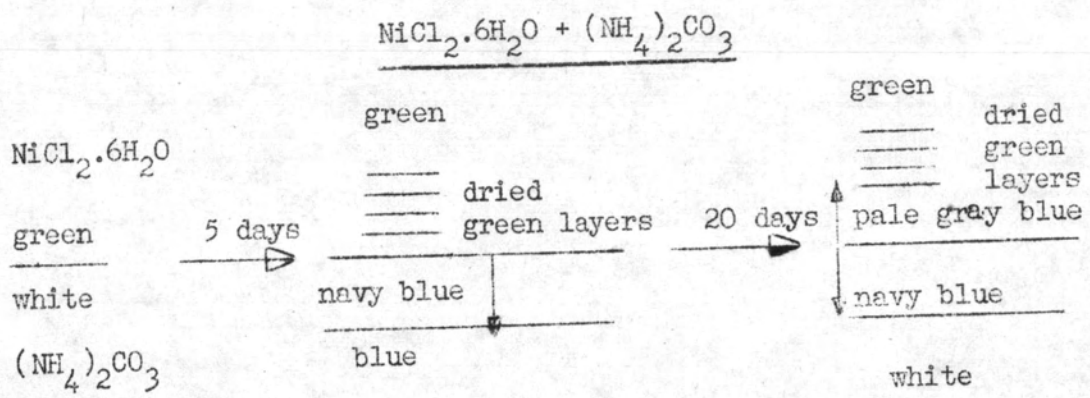


Table 5.7 Result of growth rate of solid reaction

$NiCl_2.6H_2O + (NH_4)_2CO_3$

Time	Thickness				
	$NiCl_2.6H_2O$ green (cm)	$(NH_4)_2CO_3$ white (cm)	navy blue product (cm)	green separately dried layers (cm)	pale gray--blue product (cm)
0	1.50	1.50	-	-	-
5 days	1.00	<1.50	line	0.50	-
10 days	0.80	1.30	0.20	0.70	-
20 days	0.80	1.20	0.40	0.60	0.10
30 days	0.80	1.20	0.40	0.10	0.50

$NiSO_4.6H_2O$ + KCN

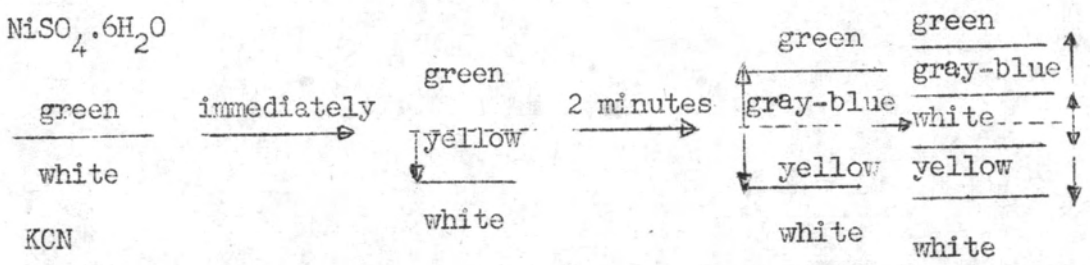


Table 5.8 Result of growth rate of solid reaction

$NiSO_4.6H_2O$ + KCN

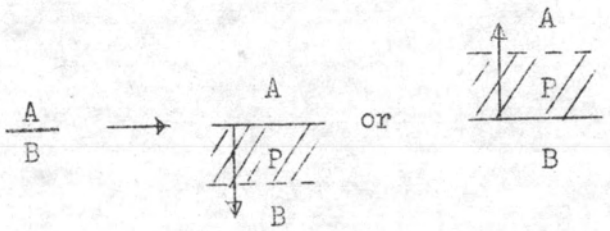
Time	Thickness				
	$NiSO_4.6H_2O$ green (cm)	KCN-white (cm)	gray-blue product (cm)	yellow product (cm)	white product (cm)
immediately	1.50	1.50	-	line	-
2 minutes	<1.50	<1.50	line	line	-
4 hours	1.40	1.40	0.10	0.10	-
1 day	1.00	0.80	0.50	0.70	-
5 days	0.40	0.50	1.10	1.00	-
11 days	0.10	0.20	1.40	1.30	line
15 days	-	-	1.40	1.30	0.30
20 days	-	-	1.10	0.90	0.70
25 days	-	-	0.90	0.40	1.40
30 days	-	-	0.50	-	2.20

The direction of colour change in solid-solid reaction as a whole can be grouped into the following product formation.

1. One product formation

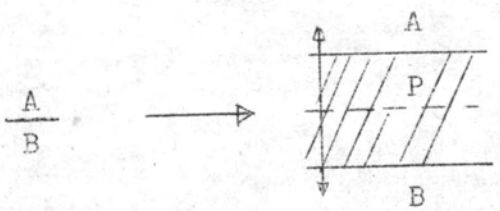
There are two different ways of formation

a. One direction growth of product.



One colour change appeared firstly at the interface and diffused increasingly in one direction only.

b. Two - direction growth of product.

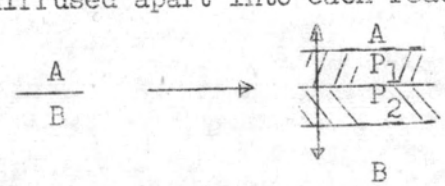


The colour change at the contact surfaces spreaded toward the two of reactants with either the same or different rate.

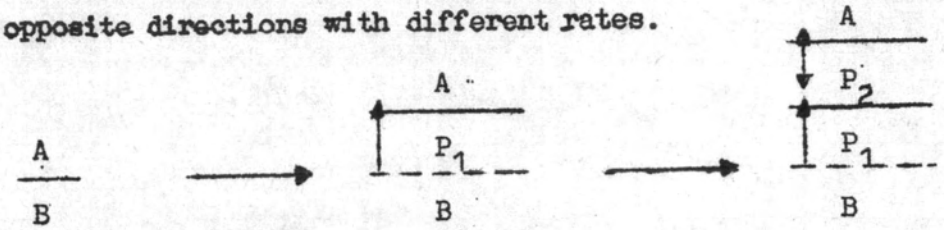
2. Two - products formation

There are two comparable direction in spreading of colour products :-

a. Two different coloured products occurred simultaneously at the interface and diffused apart into each reactant.



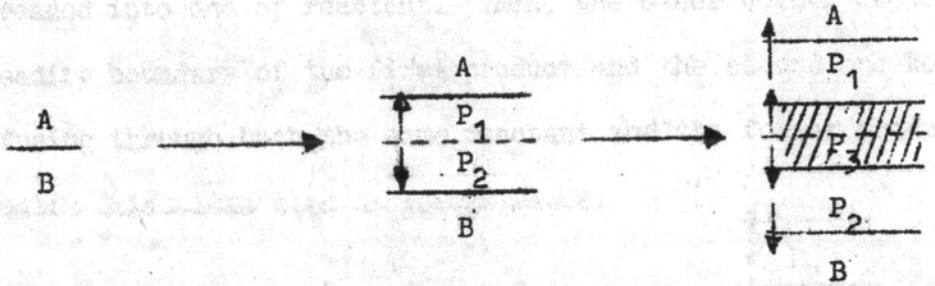
b. The first colour change appeared at reactants interface and spreaded into one of reactant. Then, the other colour occurred at spreading boundary of the first product and the second one kept on diffusing through both the same reactant and the former product in opposite directions with different rates.



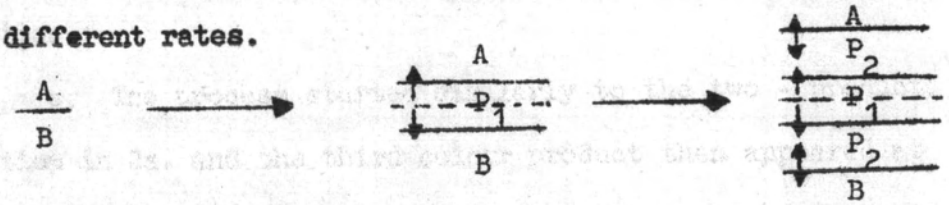
3. More than two-products formation.

Two different processes were observed in this type of formation :-

a. The process started similarly to the two - products formation in 2a. and the third colour product then appeared at the interface of these two former products then spreaded apart and migrated toward each of them.



b. The only one product was produced in the same manner as process 1b., after that another two coloured ones occurred at the two ends of the spreading area and then each of them migrated toward both of the former product and remaining reactant adjacent to it with different rates.



There were several other mechanisms which were not reported because of some slightly difference from the former explanation. It was reaction between lemon yellow potassium ferrocyanide, $K_4Fe(CN)_6.3H_2O$, and white aluminium nitrate, $Al(NO_3)_3.9H_2O$. The initial colours of these two reactants were changed completely before the first permanent green product occurred. Such was the case with the lemon yellow $K_4Fe(CN)_6.3H_2O$ which changed to green-yellow beginning at the interface and then dispersing all over $K_4Fe(CN)_6.3H_2O$, while the white $Al(NO_3)_3.9H_2O$ changed to pale blue with the same manner as $K_4Fe(CN)_6.3H_2O$ and then the first green product appeared at the interface of these green-lemon layer and pale blue layer as shown in the following

$$\frac{\text{lemon-yellow } K_4Fe(CN)_6.3H_2O}{\text{white } Al(NO_3)_3.9H_2O} \longrightarrow \frac{\text{green-yellow}}{\text{pale blue}} \longrightarrow \frac{\text{green-yellow}}{\text{-- green --}} \Big/ \text{pale blue}$$

The green product did not occur until all two reactants were completely changed. From the analysis of green-yellow and pale blue layers the results showed very few diffusion of iron species.

Several compounds of metals in the same group of periodic table had been tried to compare for getting more relationship. But unfortunately,(the observation) showed the unconcerned results with the other properties of compounds of the same group metals such as the number of products, direction of product growth, type of each product and etc., and even more, they seem to be independent

It can be seen that the number of products in the same reaction which observed in 5.2 were much more than in 5.1. More information may be obtained by further developing experimental techniques.

5.3 Percentage determination of heavy elements in some products from solid-solid reaction by X-ray fluorescence technique.

Table 5.9 Data for the Calibration curve

Reactants			Gram ratio of mixture (A : B)			
A	B		1 : 4	2 : 3	3 : 2	4 : 1
$MnCl_2 \cdot 4H_2O$	$Ca(OH)_2$	%MnCalc.	5.4610	10.9220	16.3830	21.8440
		Activity	173±2	651±5	1114±8	1676±11
$K_4Fe(CN)_6 \cdot 3H_2O$	$Al(NO_3)_3 \cdot 9H_2O$	%Fe.Calc.	2.6442	5.2884	7.9326	10.5768
		Activity	1723±8	2427±12	3192±15	3915±19
$K_4Fe(CN)_6 \cdot 3H_2O$	$AgNO_3$	%Fe.Calc.	2.6442	5.2884	7.9326	10.5768
		Activity	1135±6	1319±10	1531±12	1798±14
		%Ag.Calc.	55.3860	41.5359	27.6930	73.8465
		Activity	30514±183	25532±153	20758±124	15362±92
$SnCl_2 \cdot 2H_2O$	$Bi(NO_3)_3 \cdot 5H_2O$	%Sn.calc.	10.5209	21.0418	31.5627	42.0836
		Activity	3794±22	8040±48	13340±80	18254±109
		%Bi.calc.	34.4656	25.8492	17.2328	8.6164
		Activity	10248±71	8039±56	5235±36	3287±23
$SnCl_2 \cdot 2H_2O$	KI	%Sn.calc.	10.5209	21.0418	31.5627	42.0836
		Activity	8990±71	15032±90	21008±126	27251±163
		%I.calc.	61.1562	45.8671	30.5780	15.2890
		Activity	21928±153	18511±92	14586±87	10691±64

Activity = Count number per 200 seconds.

Table 5.9 (Continued)

Reactants			Gram ratio of mixture (A : B)			
A	B		1 : 4	2 : 3	3 : 2	4 : 1
$CdBr_2$	$Na_2SO_3 .7H_2O$	%Cd.calc.	8.2580	16.5161	24.7742	33.0323
		Activity	9301±55	10850±75	12394±74	13779±96
		%Br.calc.	5.8709	11.7419	17.6128	23.4838
		Activity	10290±61	14250±21	18435±110	21921±109

Activity = Count number per 200 seconds.

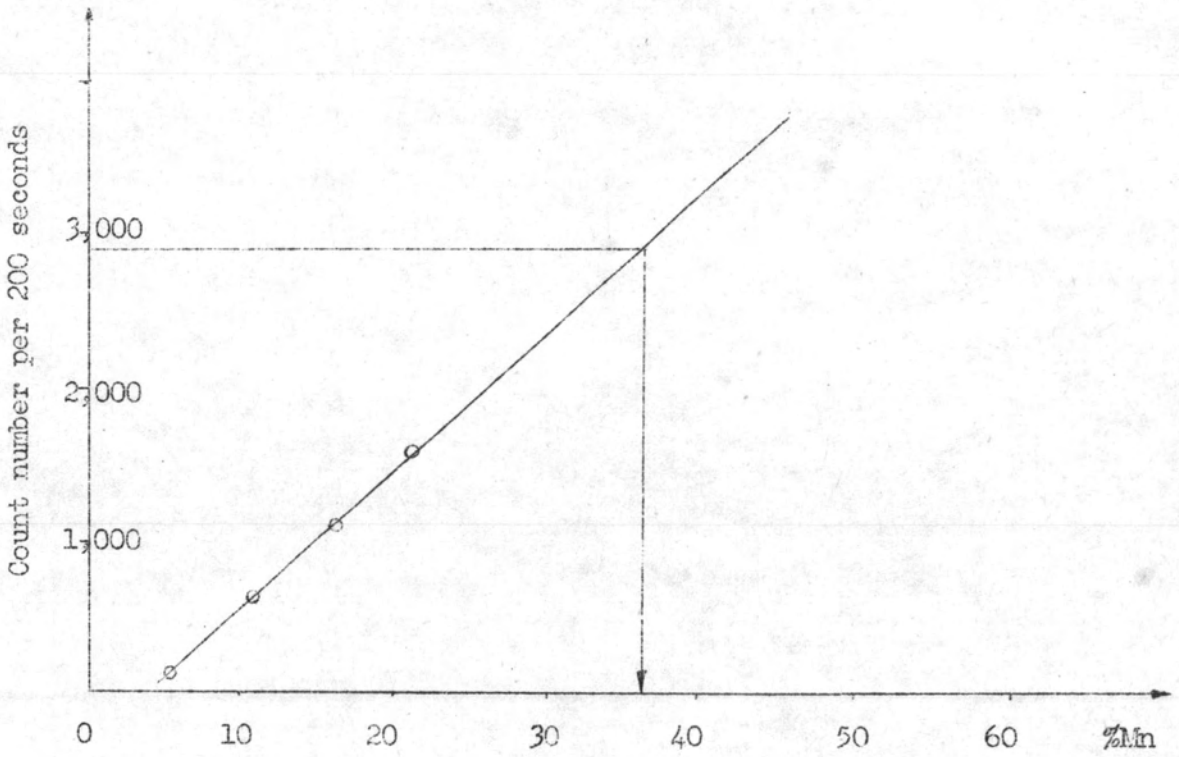


Fig 5.1 Calibration curve of Manganese in reaction $MnCl_2.4H_2O + Ca(OH)_2$

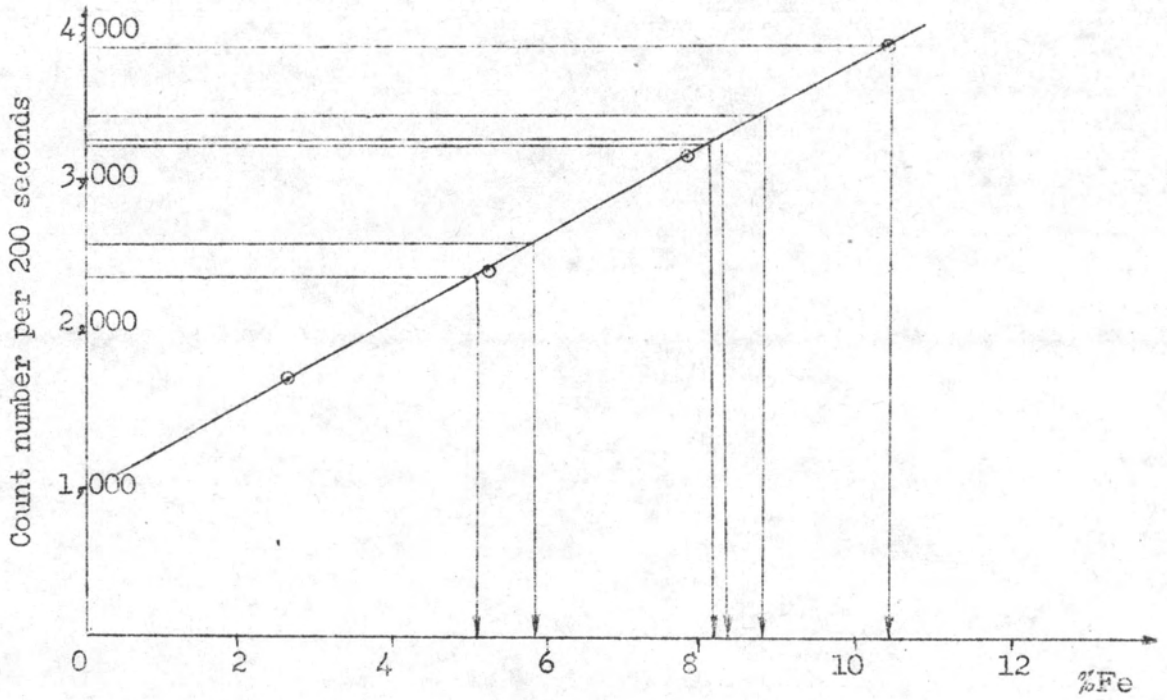


Fig 5.2 Calibration curve of Iron in reaction
$K_4Fe(CN)_6.3H_2O + Al(NO_3)_3.9H_2O$

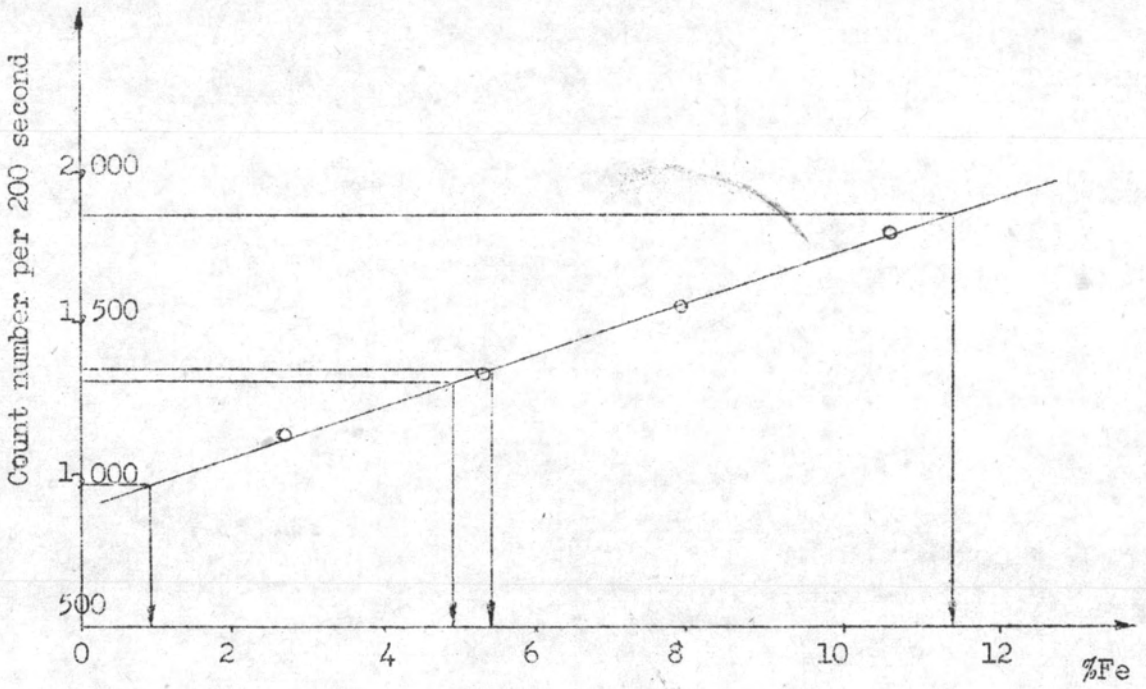


Fig 5.3 Calibration curve of Iron in reaction $K_4Fe(CN)_6.3H_2O + AgNO_3$

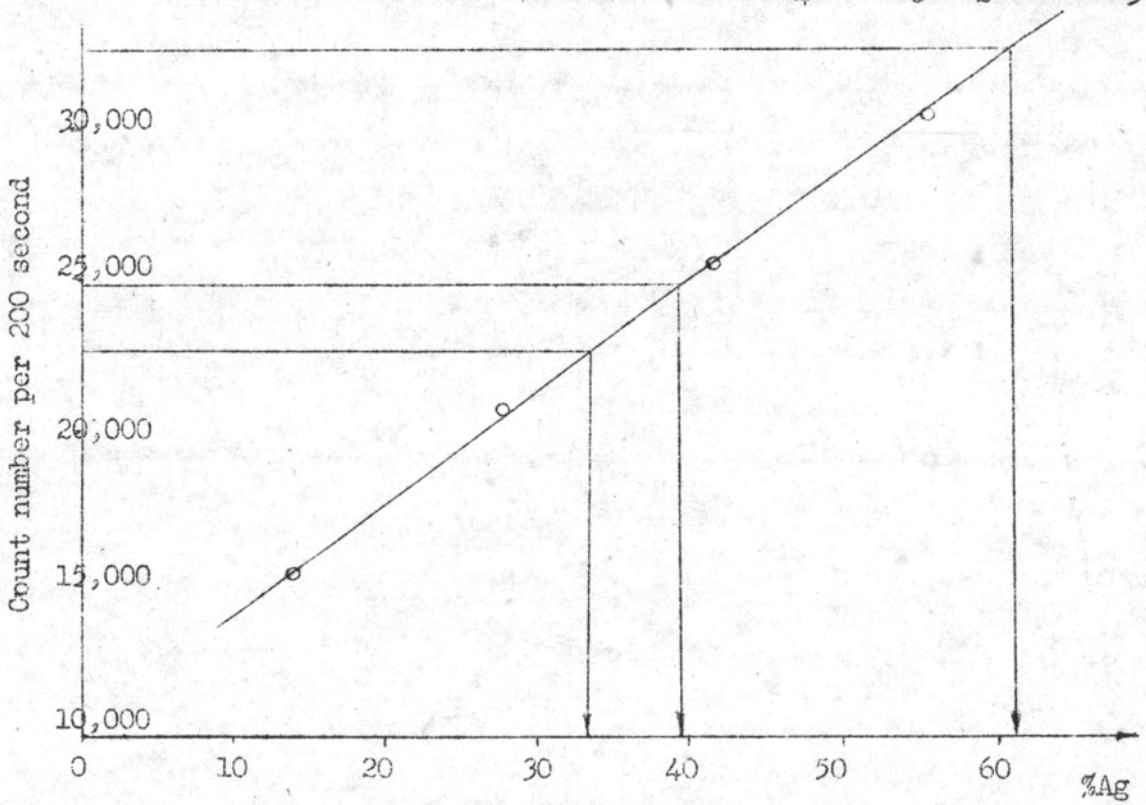


Fig 5.4 Calibration curve of Silver in reaction $K_4Fe(CN)_6.3H_2O + AgNO_3$

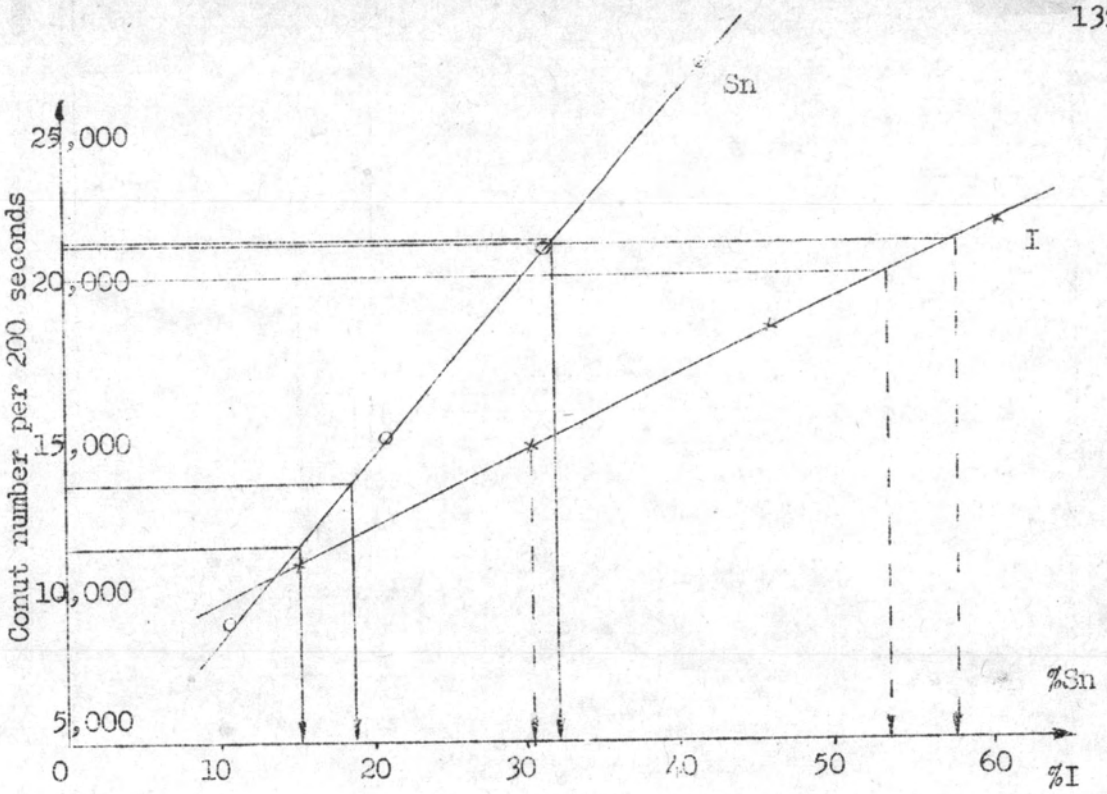


Fig 5.5 Calibration curve of Tin and Iodine in $SnCl_2.2H_2O$ + KI

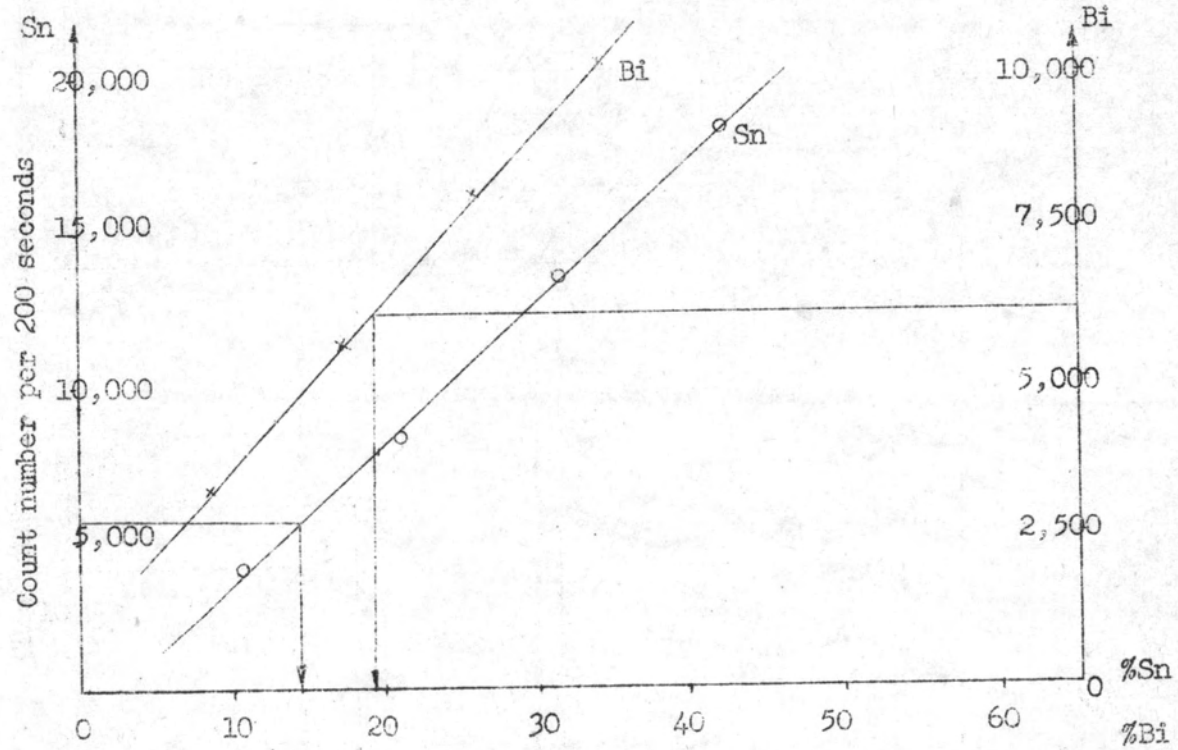


Fig 5.6 Calibration curve of Tin and Bismuth in reaction $SnCl_2.2H_2O + Bi(NO_3)_3.5H_2O$

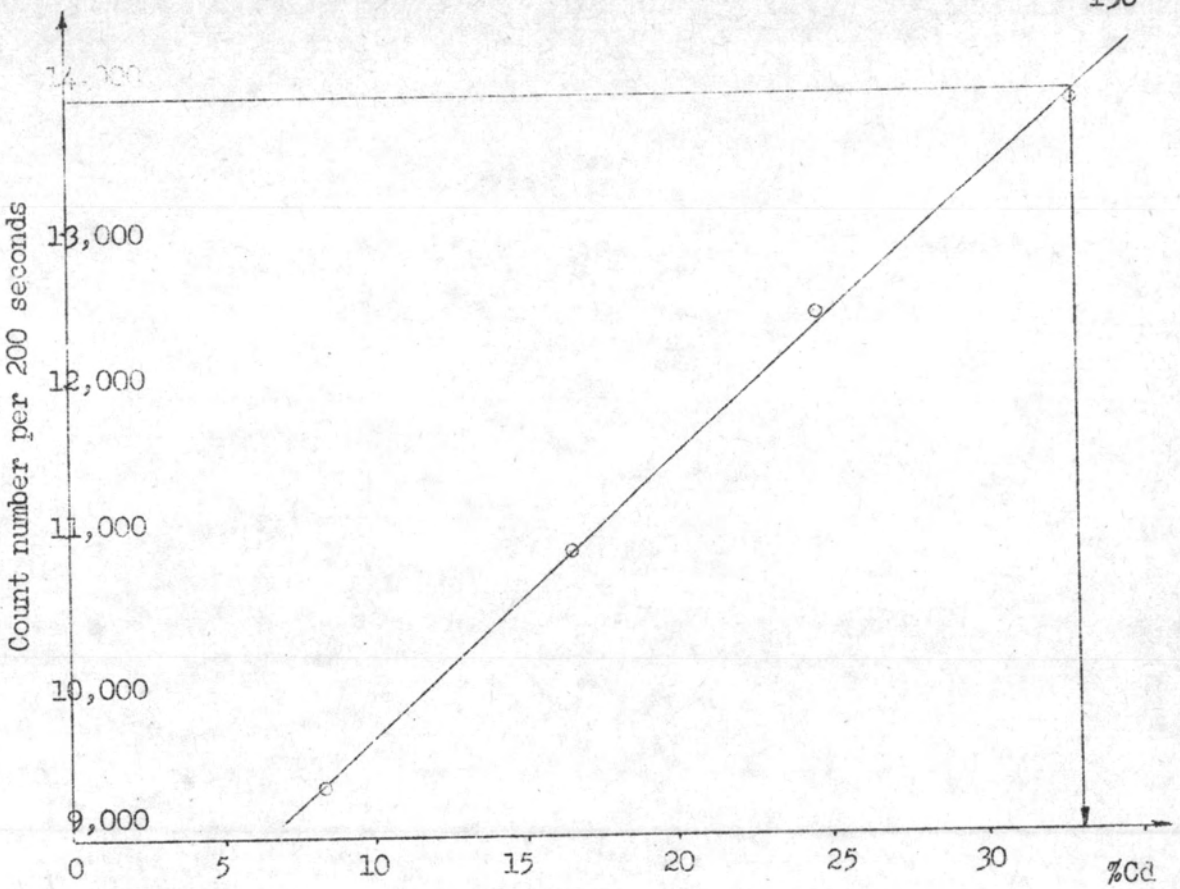


Fig 5.7 Calibration curve of Cadmiam in reaction $CdBr_2 + Na_2SO_3.7H_2O$

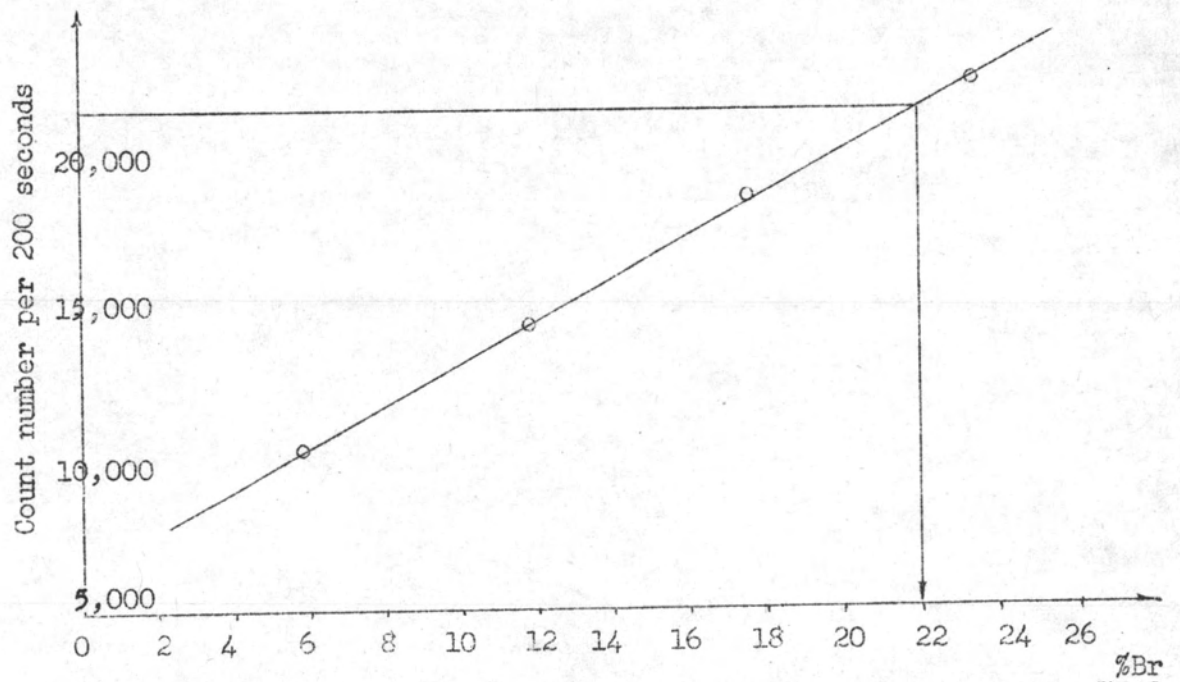


Fig 5.8 Calibration curve of Bromine in reaction $CdBr_2 + Na_2SO_3.7H_2O$

Table 5.10 Result of percentage determination of heavy elements in some products from solid-solid reaction by X-ray fluorescence technique.

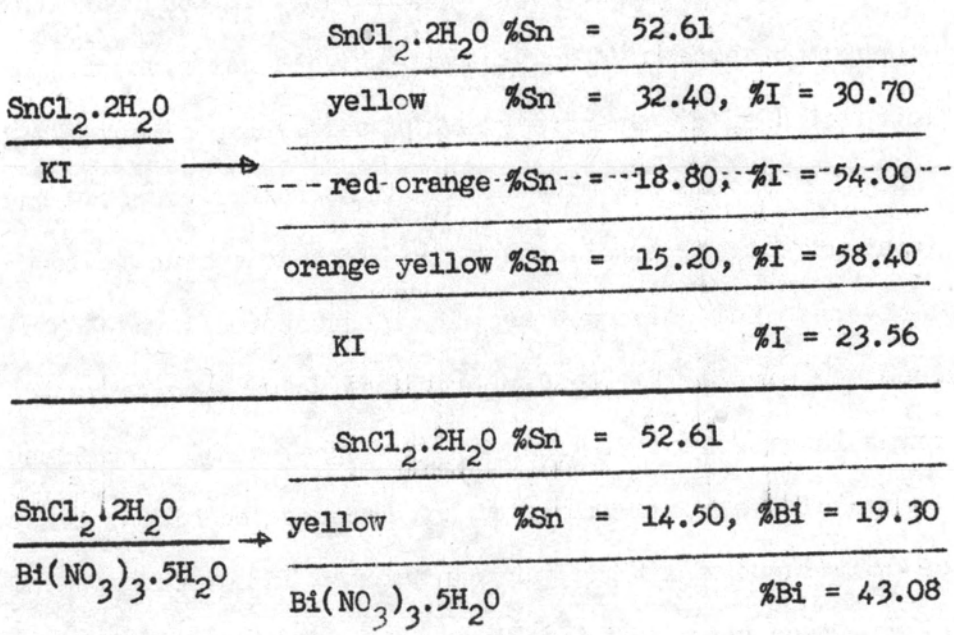
System	Product colour	Activity (c.p. 200 sec)	Expt. percentage of some elements	
$MnCl_2.4H_2O + Ca(OH)_2$	black-brown	2882 ± 17	%Mn	36.50
$K_4Fe(CN)_6.3H_2O +$ $Al(NO_3)_3.9H_2O$	pale blue	302 ± 1.81	%Fe	very little
	green-yellow	3903 ± 23	%Fe	10.50
	yellow-green	3468 ± 20	%Fe	8.90
	dark-green	3313 ± 23	%Fe	8.40
	green	2625 ± 16	%Fe	5.90
	green-blue	2410 ± 14	%Fe	5.12
	blue	3258 ± 19	%Fe	8.25
$K_4Fe(CN)_6.3H_2O +$ $AgNO_3$	green	1853 ± 13	%Fe	11.45
		6318 ± 38	%Ag	very little
	brown	959 ± 5.75	%Fe	0.95
		32708 ± 196	%Ag	61.00
	green-blue	1333 ± 8	%Fe	5.43
		22752 ± 182	%Ag	33.40
	blue	1301 ± 7	%Fe	4.92
		24967 ± 124	%Ag	39.50
$SnCl_2.2H_2O +$ $Bi(NO_3)_3.5H_2O$	yellow	5460 ± 32	%Sn	14.50
		6126 ± 36	%Bi	19.30

Table 5.10 (Continued)

System	Product colour	Activity (c.p. 200 sec)	Expt. percentage of some elements	
$SnCl_2.2H_2O$ + KI	yellow	21486 ± 150	%Sn	32.40
		14605 ± 88	%I	30.70
	orange-yellow	11448 ± 68	%Sn	15.20
		21284 ± 127	%I	58.40
	red-orange	13658 ± 95	%Sn	18.80
		20308 ± 142	%I	54.00
$CdBr_2$ + $Na_2SO_3.7H_2O$	yellow	13879 ± 69	%Cd	33.20
		21296 ± 127	%Br	22.10

The quantity of heavy element appeared in product layer indicated the diffusibility of such element, diffused direction, and some information for the composition of product compound. The variation in quantities of heavy elements in each layer of reactants and products indicated the newly formed compound and might be the chemical change of solid-solid reaction. The instrumental result from X-ray fluorescence technique supported the observed result, the colour change, which was firstly used to indicate the occurrence of reaction. Other techniques of analysis for every elements in solid state should be searched for obtaining much more information about the composition of complex product and the mechanism of such reaction. Solvation technique was not suitable for study chemistry of the complex compound from solid-solid reaction.

Diagram of percentage comparison between heavy elements of reactants and products



$MnCl_2.4H_2O$
$Ca(OH)_2$ ⟶

$MnCl_2.4H_2O$	%Mn = 27.76
black brown	%Mn = 36.50
$Ca(OH)_2$	

$CdBr_2$
$Na_2SO_3.7H_2O$ ⟶

$CdBr_2$	%Cd = 41.30, %Br = 58.70
yellow	%Cd = 33.20, %Br = 22.10
$Na_2SO_3.7H_2O$	

$K_4Fe(CN)_6.3H_2O$
$AgNO_3$ ⟶

$K_4Fe(CN)_6.3H_2O$	%Fe = 13.22
green	%Fe = 11.45, %Ag very little
green-blue	%Fe = 5.43, %Ag = 33.40
blue	%Fe = 4.92, %Ag = 39.50
brown	%Fe = 0.95, %Ag = 61.00
$AgNO_3$	%Ag = 63.50

$K_4Fe(CN)_6.3H_2O$
$Al(NO_3)_3.9H_2O$ ⟶

green-yellow	%Fe = 10.50
yellow-green	%Fe = 8.90
dark green	%Fe = 8.40
green-blue	%Fe = 5.12
blue	%Fe = 8.25
pale blue	%Fe = very little

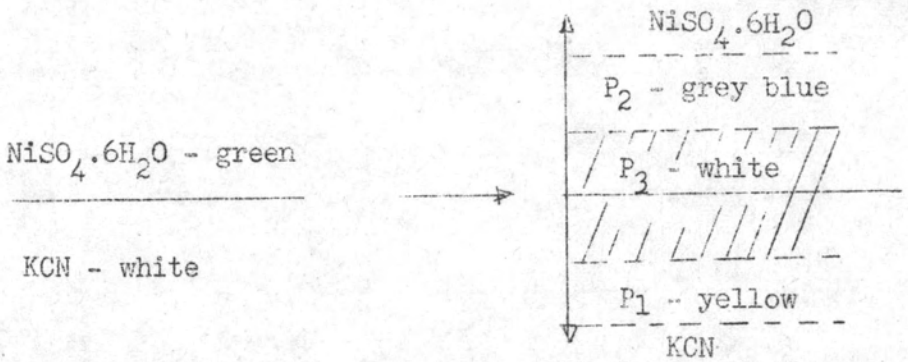
5.4 Examination of complex product by infrared spectroscopic method.

Infrared spectroscopy has proved to be a most useful tool in structural determination and identification of chemical composition. This method of analysis has the advantage of being rapid and unambiguous, it can easily be applied to small quantities of sample especially in solid state condition. But in contrast to organic compound, only few infrared spectra of inorganic compounds are available for reference.

The spectra of reactants and product (s) of the same reaction were compared and shown in Fig 5.9.1 - 5.9.29. This result may be useful for further structural study. The standard spectra of inorganic compounds which have been collected and catalogued are used for comparable study (37). The spectra - pattern of many products showed the complexity and not identical to any of the standard ones. However, they might be kept for future studies of structure of such complex. So far the results only showed the difference of products from starting materials.

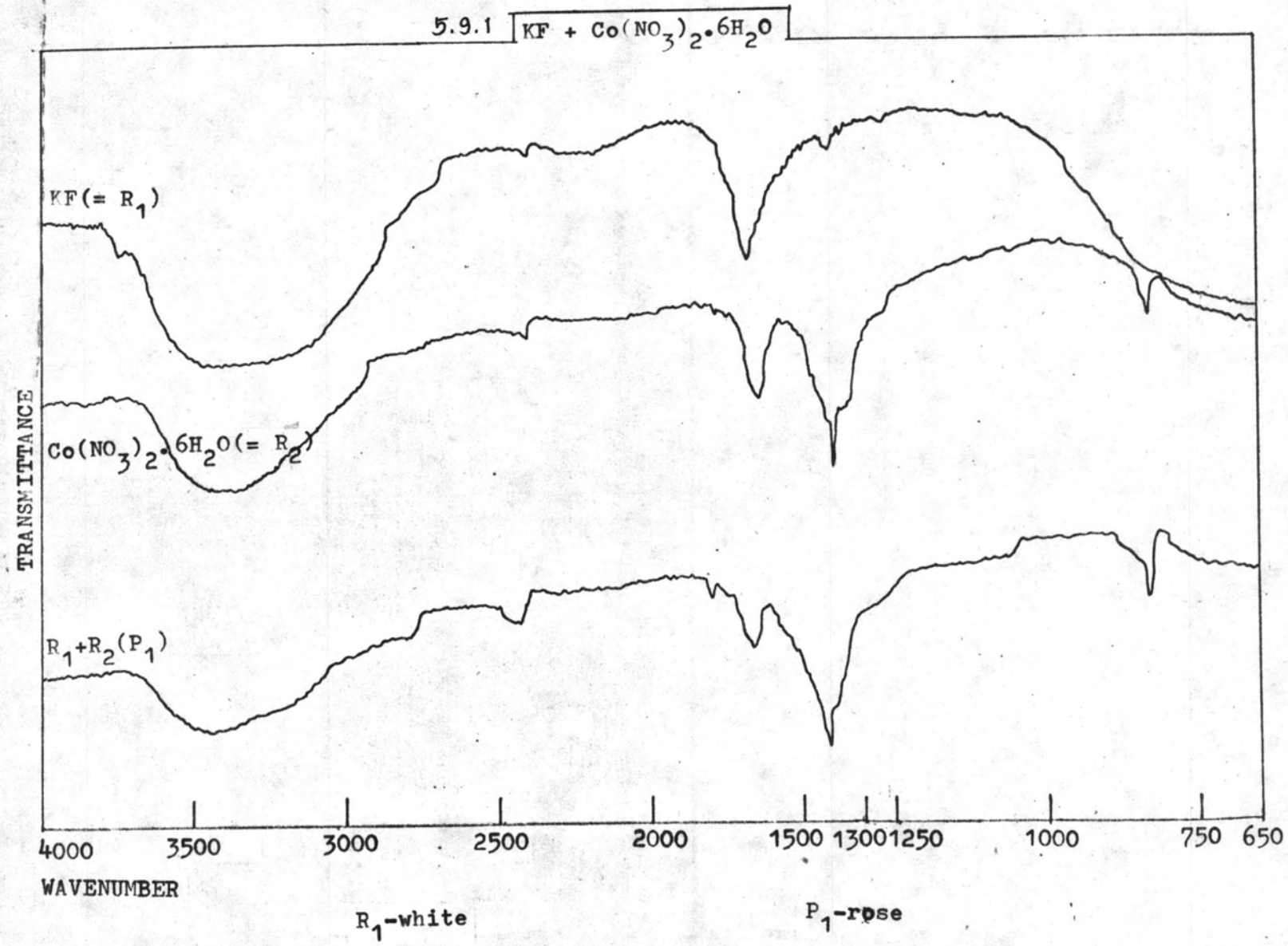
The standard spectra of products from reaction between $NiSO_4.6H_2O$ (green) and KCl (white) were yellow (P_1), gray-blue (P_2) and white (P_3). The layer structure of the reaction was

represented diagramatically below.



The third product, which was white colour, showed the equivalent spectra peak as $Ni(CN)_2$ but yellow and grey-blue products showed the different spectra peak from the reactant species, which of them have not been collected and reported as standard spectra. The results also indicated the direction and species which diffused through solid layer.

Fig. 5.9 IR pattern of reactants and products of solid-solid reaction.

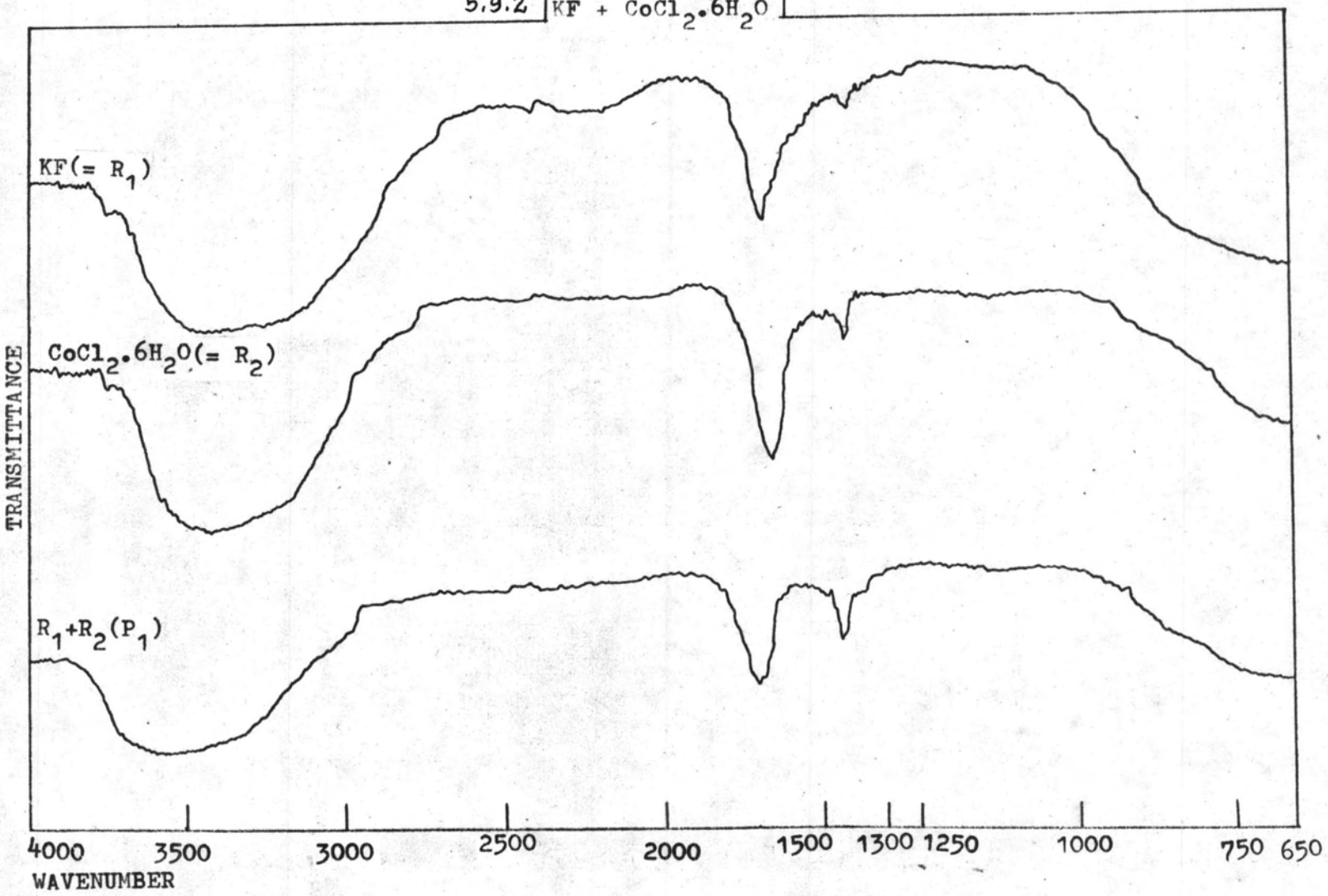


R_1-white

P_1-rose

R_2-red

5.9.2 KF + $CoCl_2 \cdot 6H_2O$

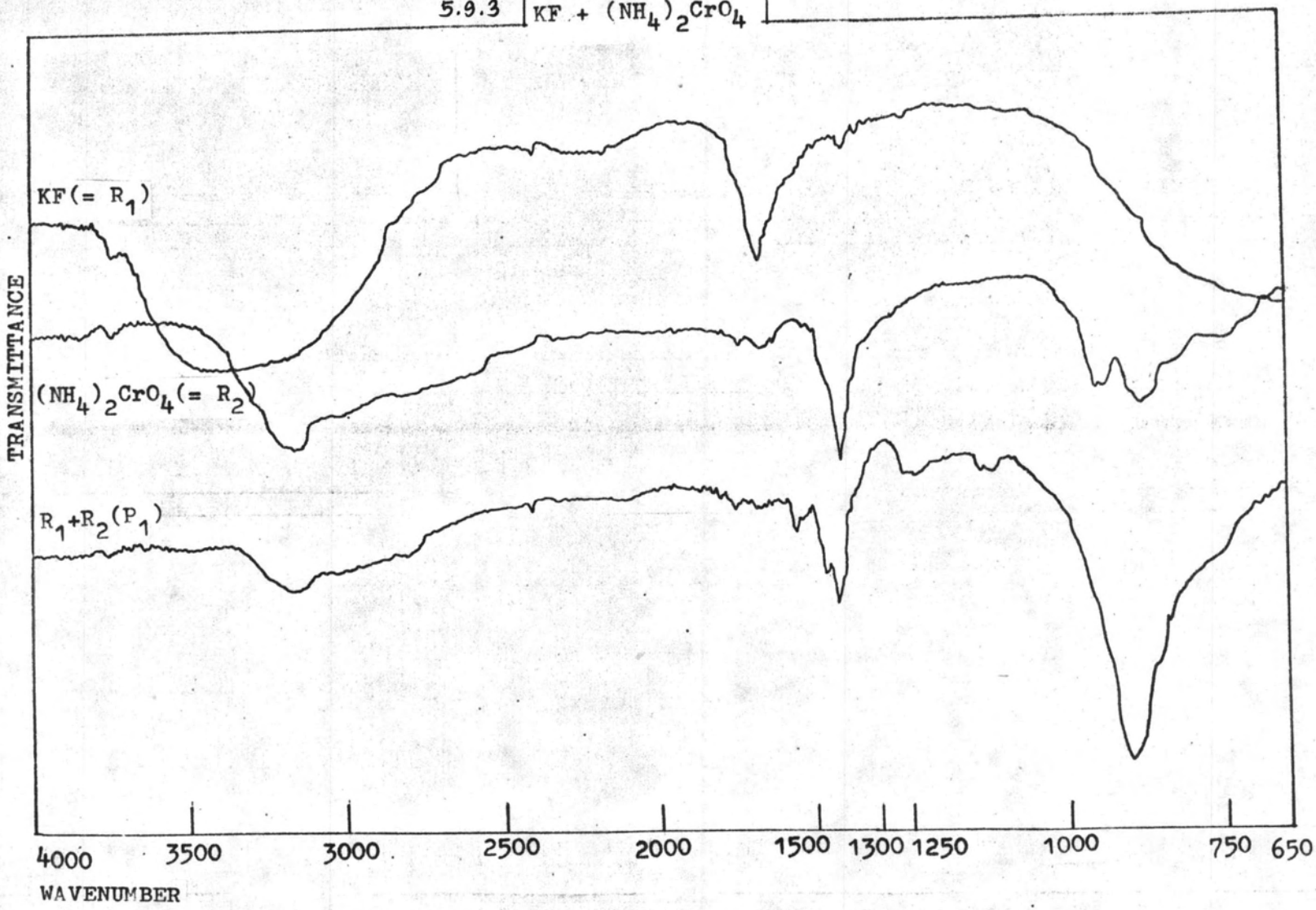


R_1-white

P_1-purple

R_2-red-violet

5.9.3 $KF + (NH_4)_2CrO_4$

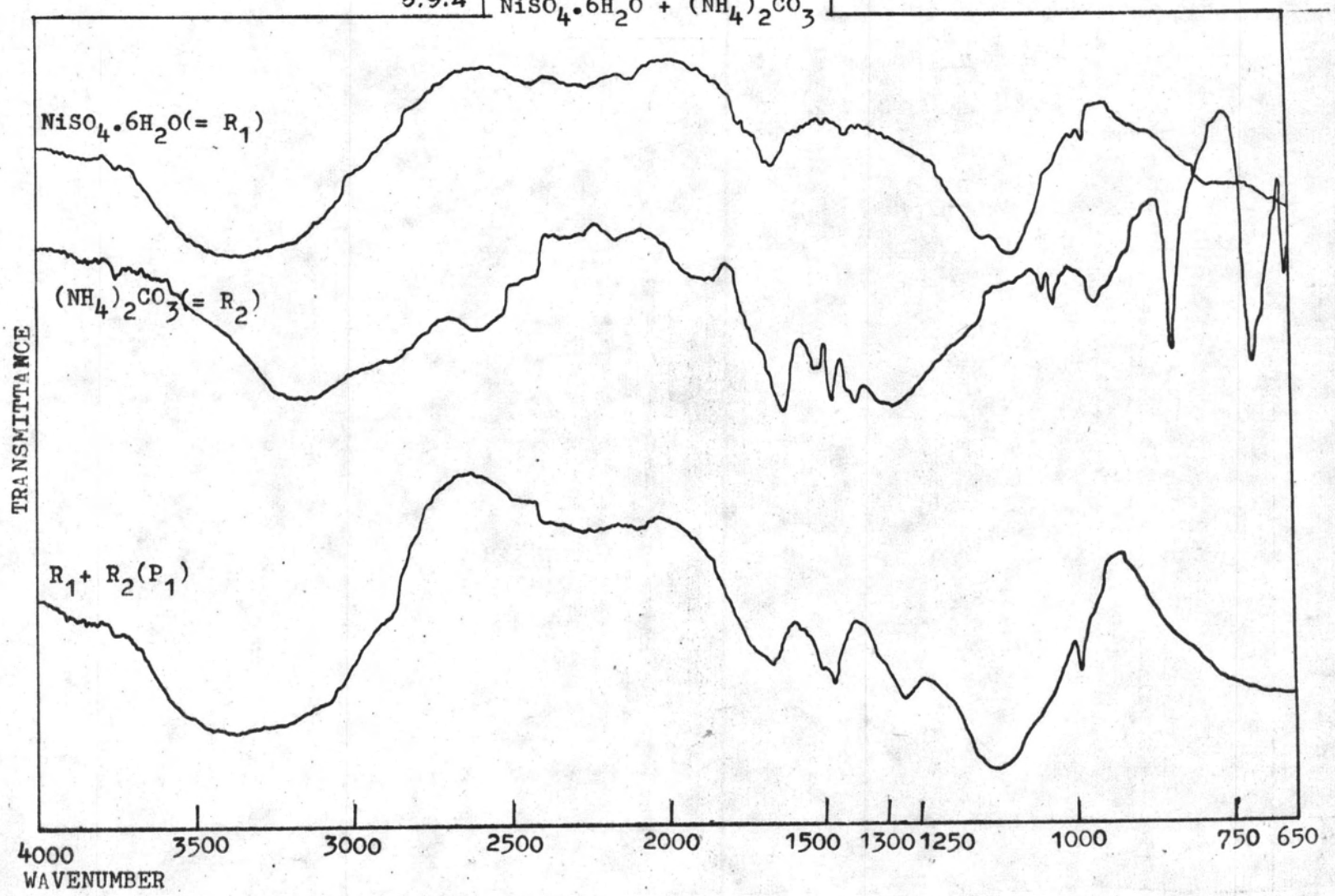


R_1-white

P_1-yellow

R_2-yellow-brown

5.9.4 $NiSO_4 \cdot 6H_2O + (NH_4)_2CO_3$

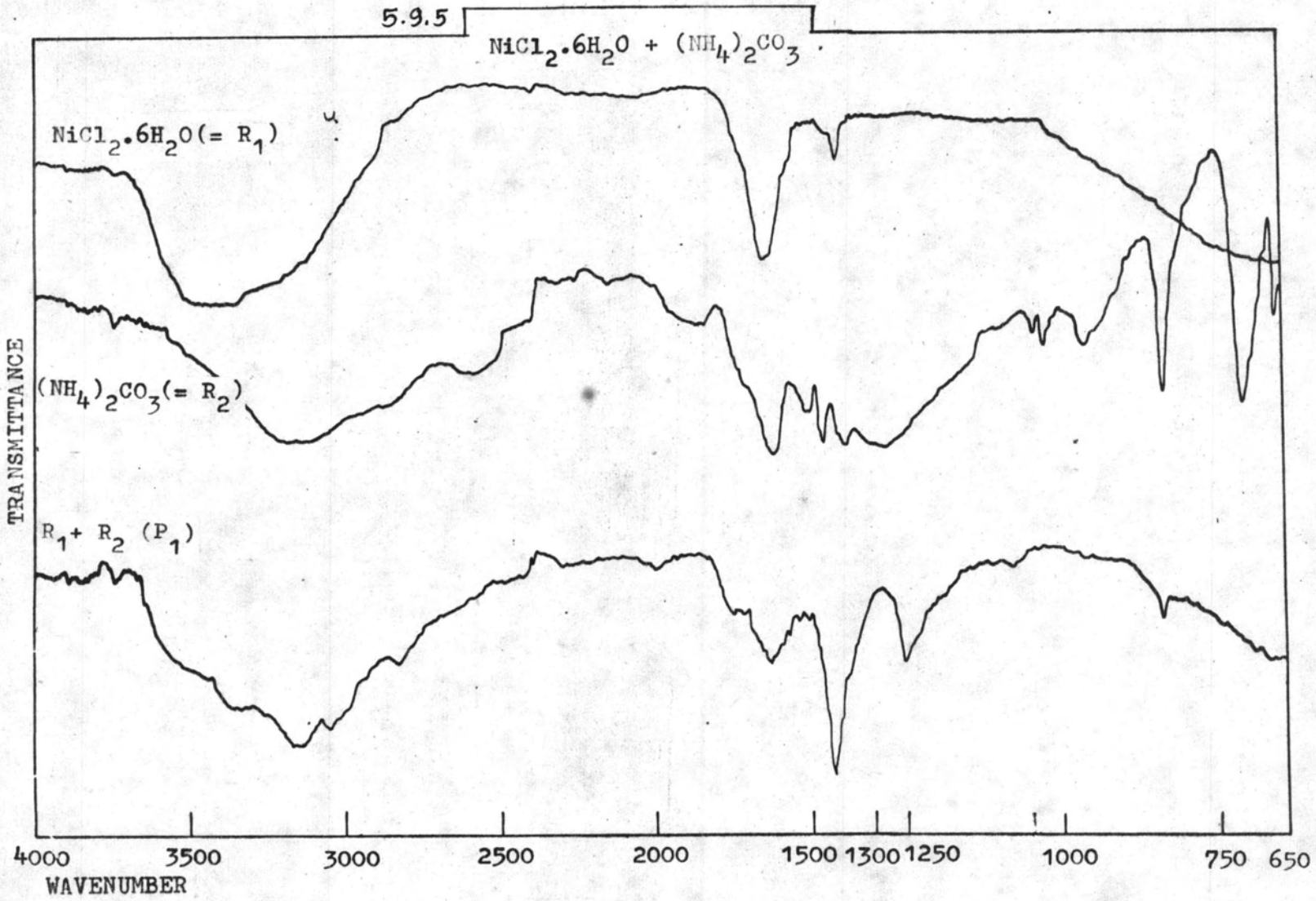


R_1-green

P_1-fleshly blue

R_2-white

5.9.5

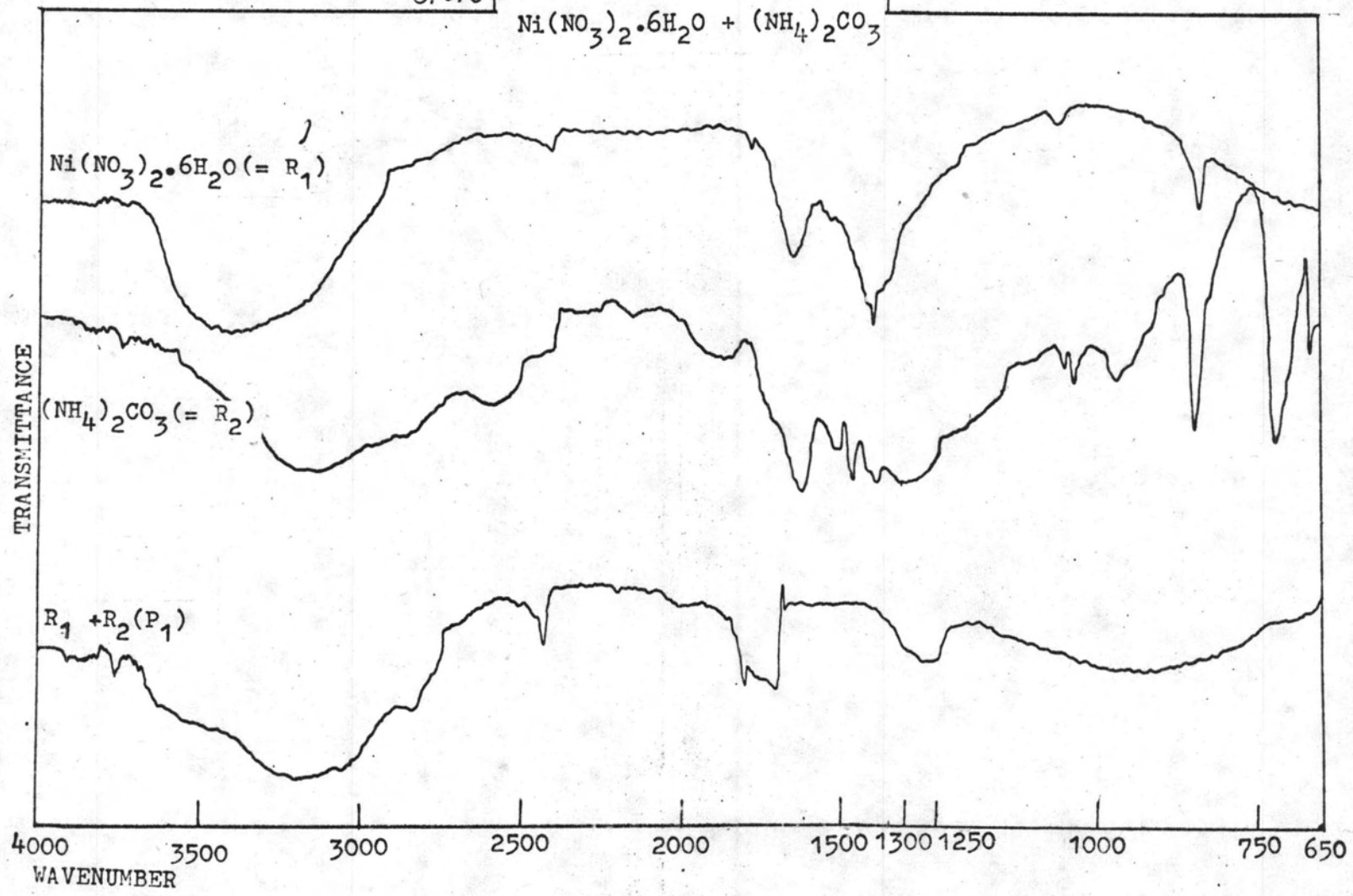


R_1-green

P_1-yellow-green

R_2-white

5.9.6

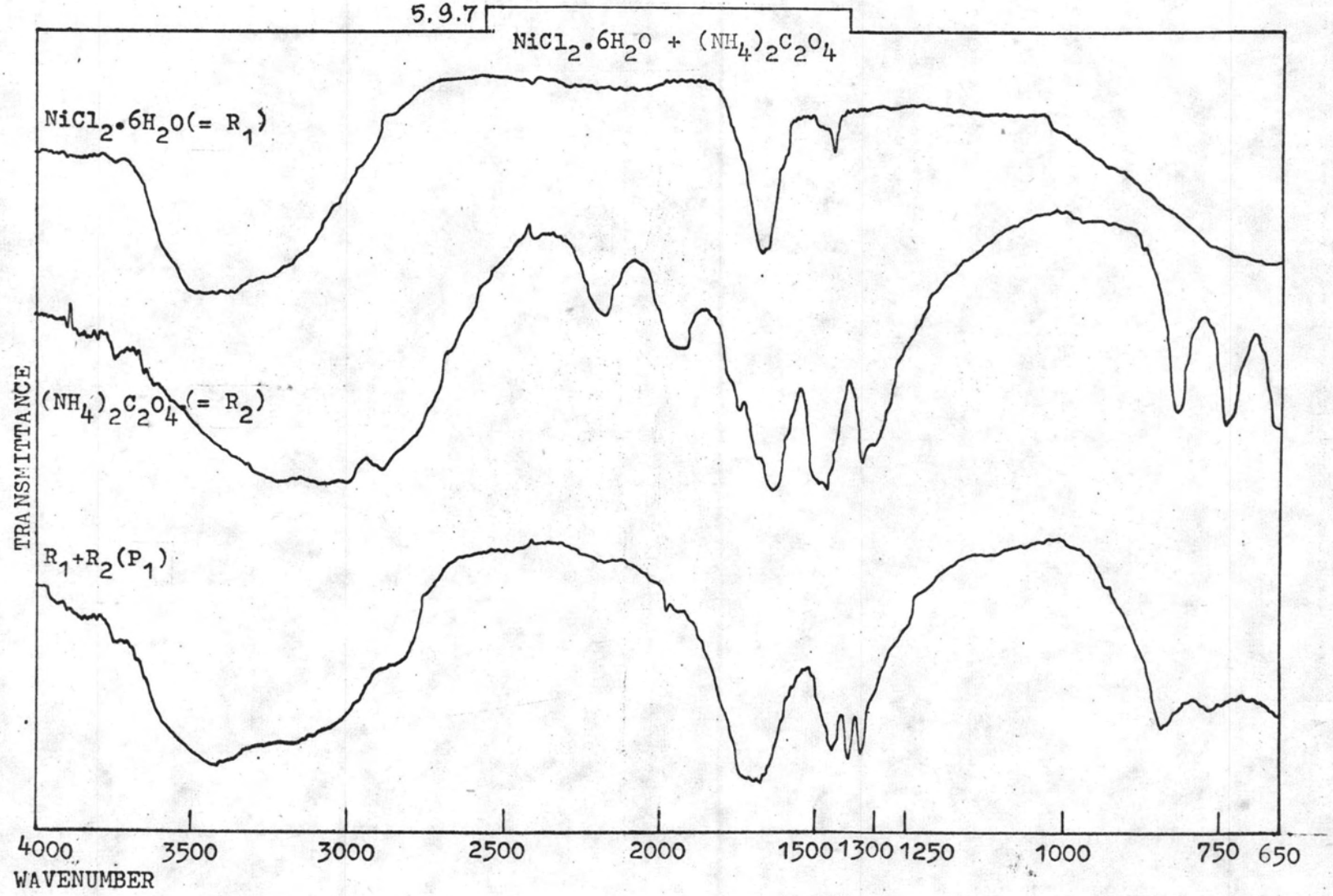


R_1-green

P_1-yellow-green

R_2-white

5.9.7

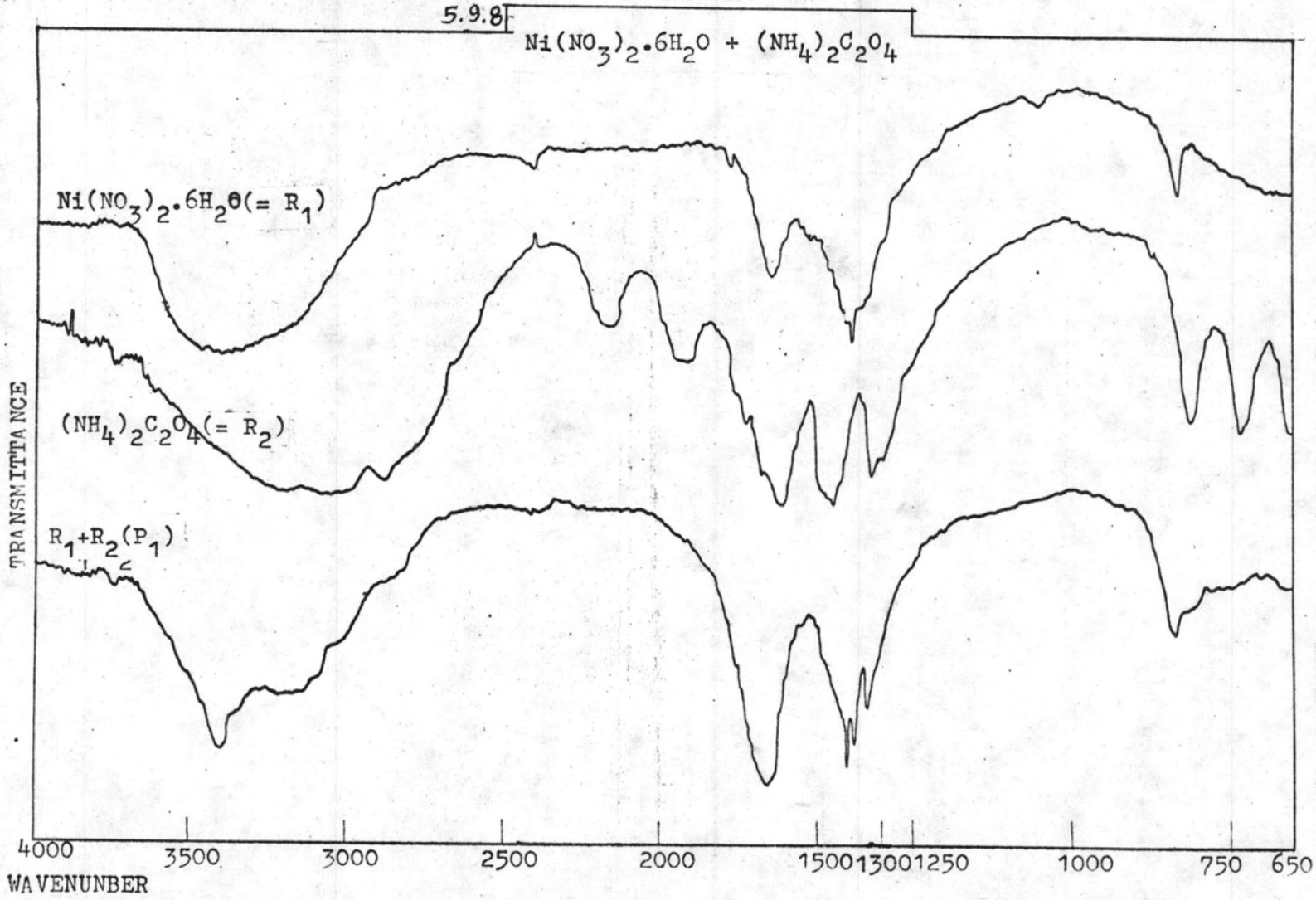


R_1-green

P_1-green-blue

R_2-white

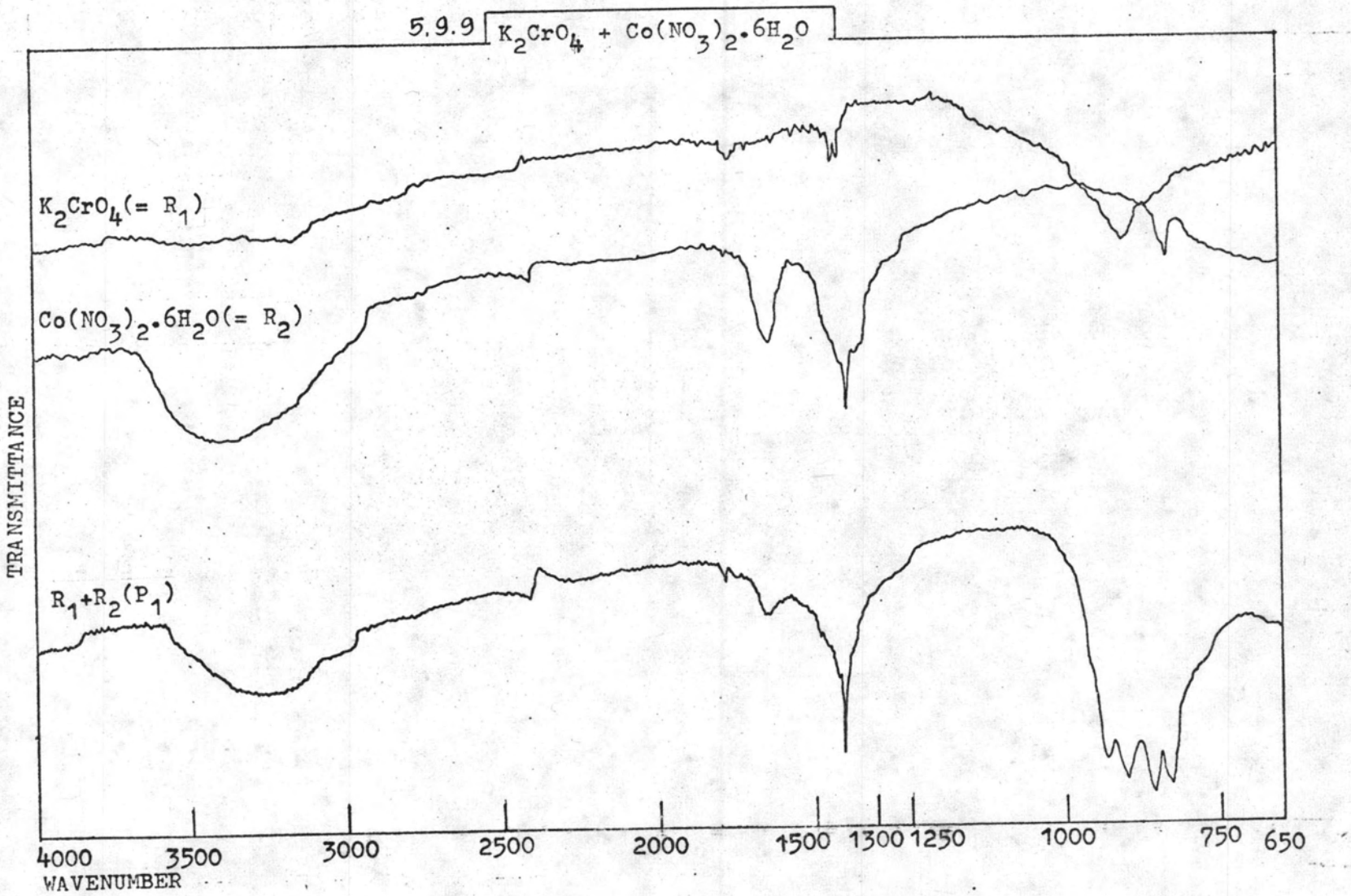
5.9.8



R_1-green

P_1-pale blue-green

R_2-white

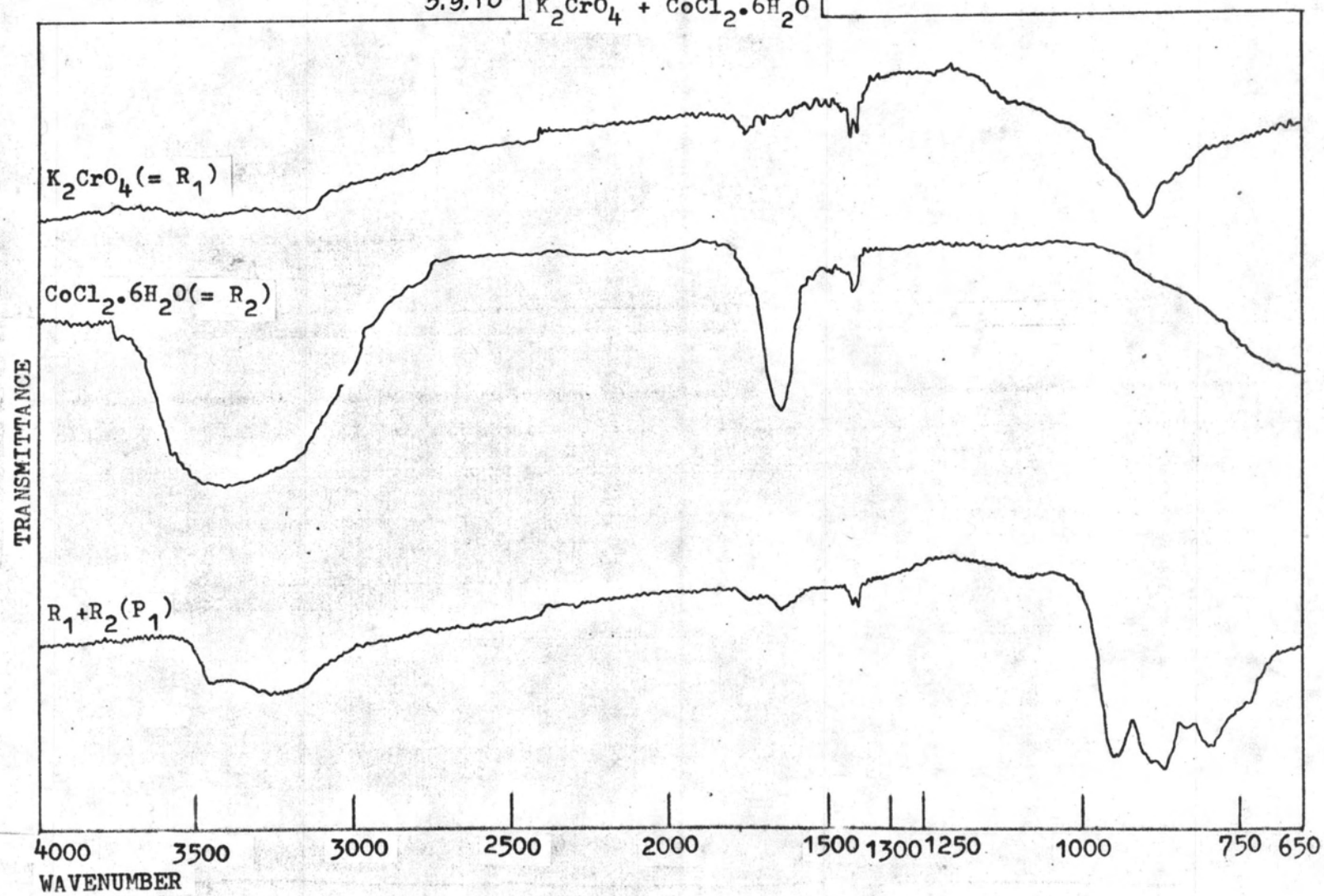


R_1-yellow

P_1-red-brown

R_2-red

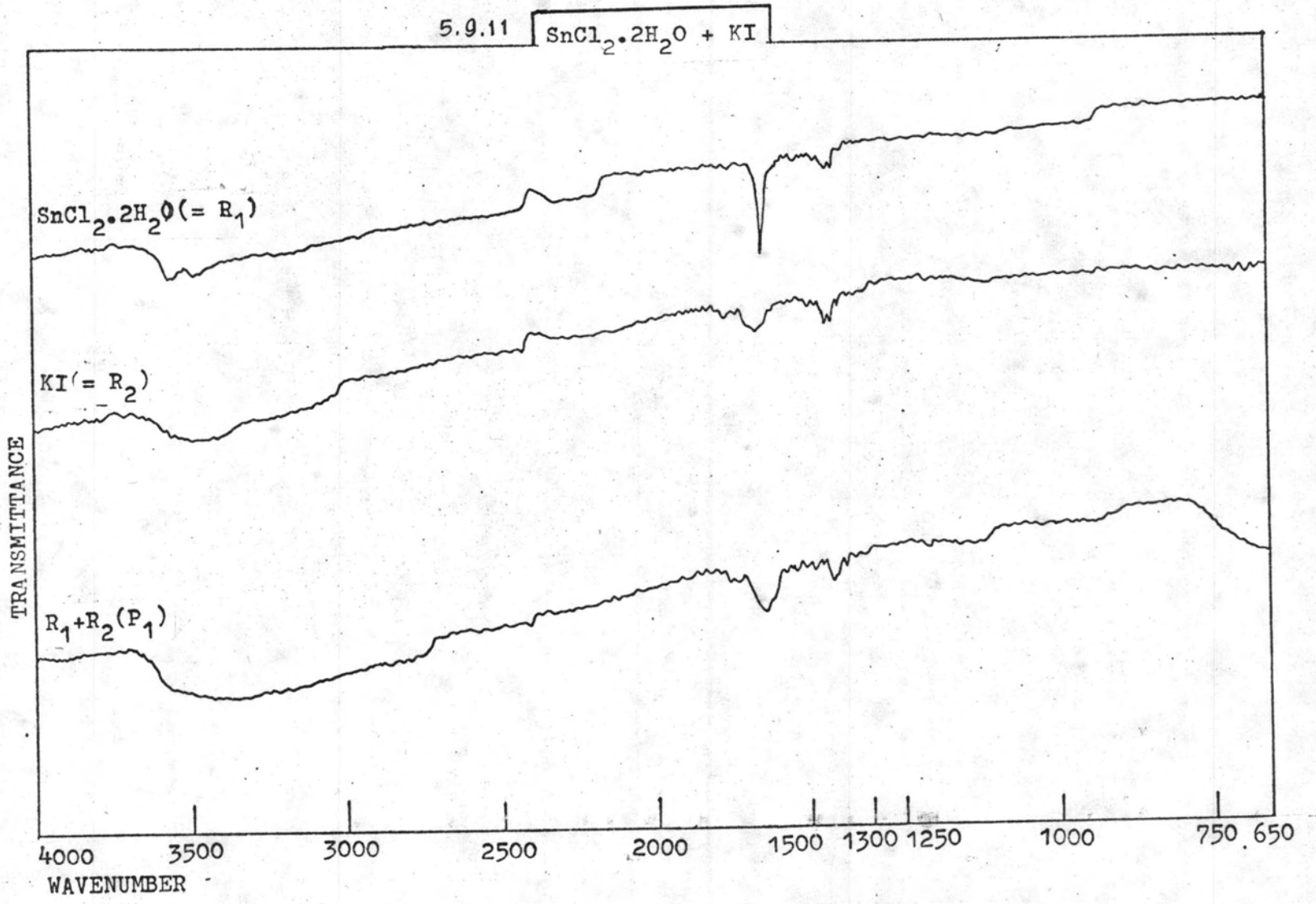
5.9.10 $K_2CrO_4 + CoCl_2 \cdot 6H_2O$



R_1-yellow

R_2-red-violet

P_1-dark-brown

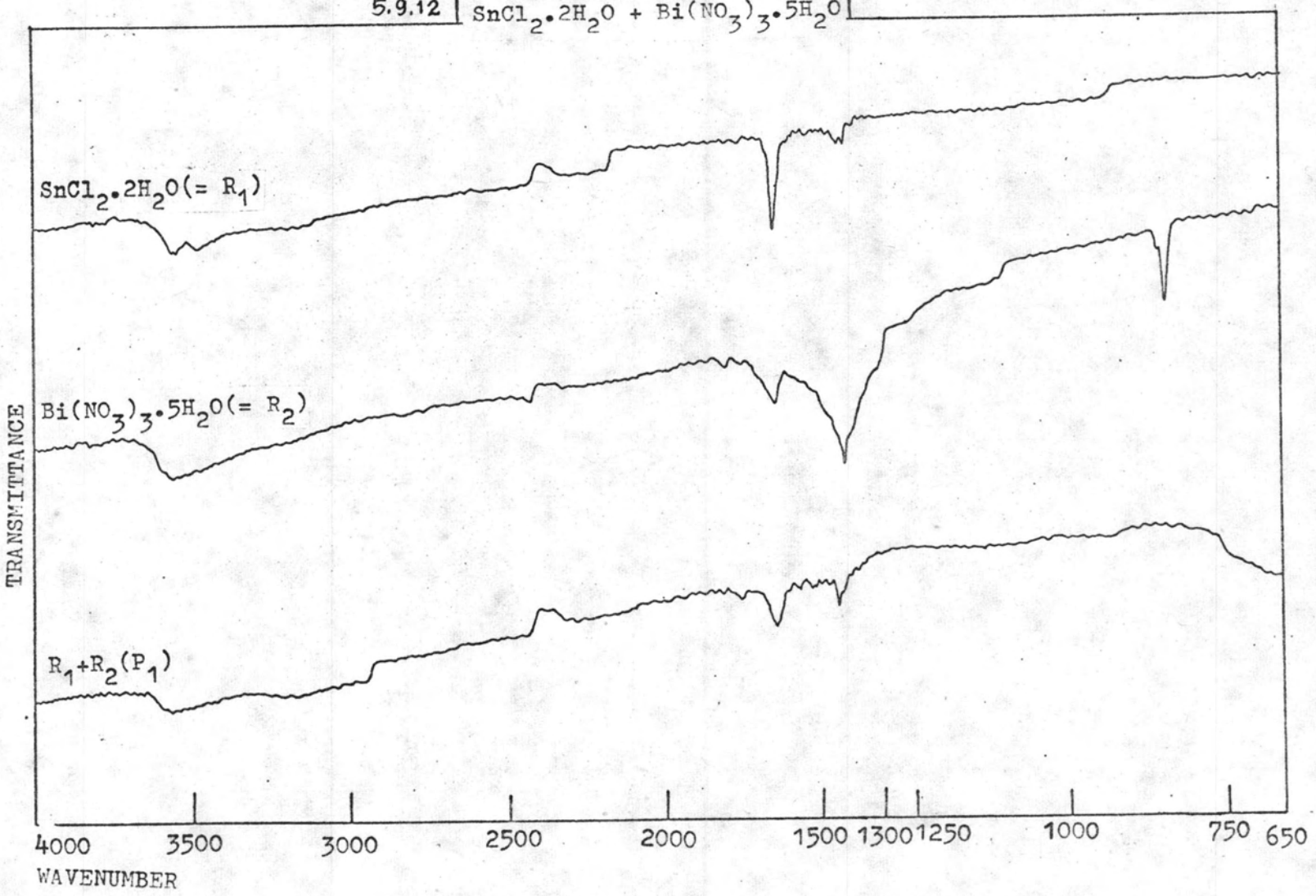


R_1-white

P_1-red-orange

R_2-white

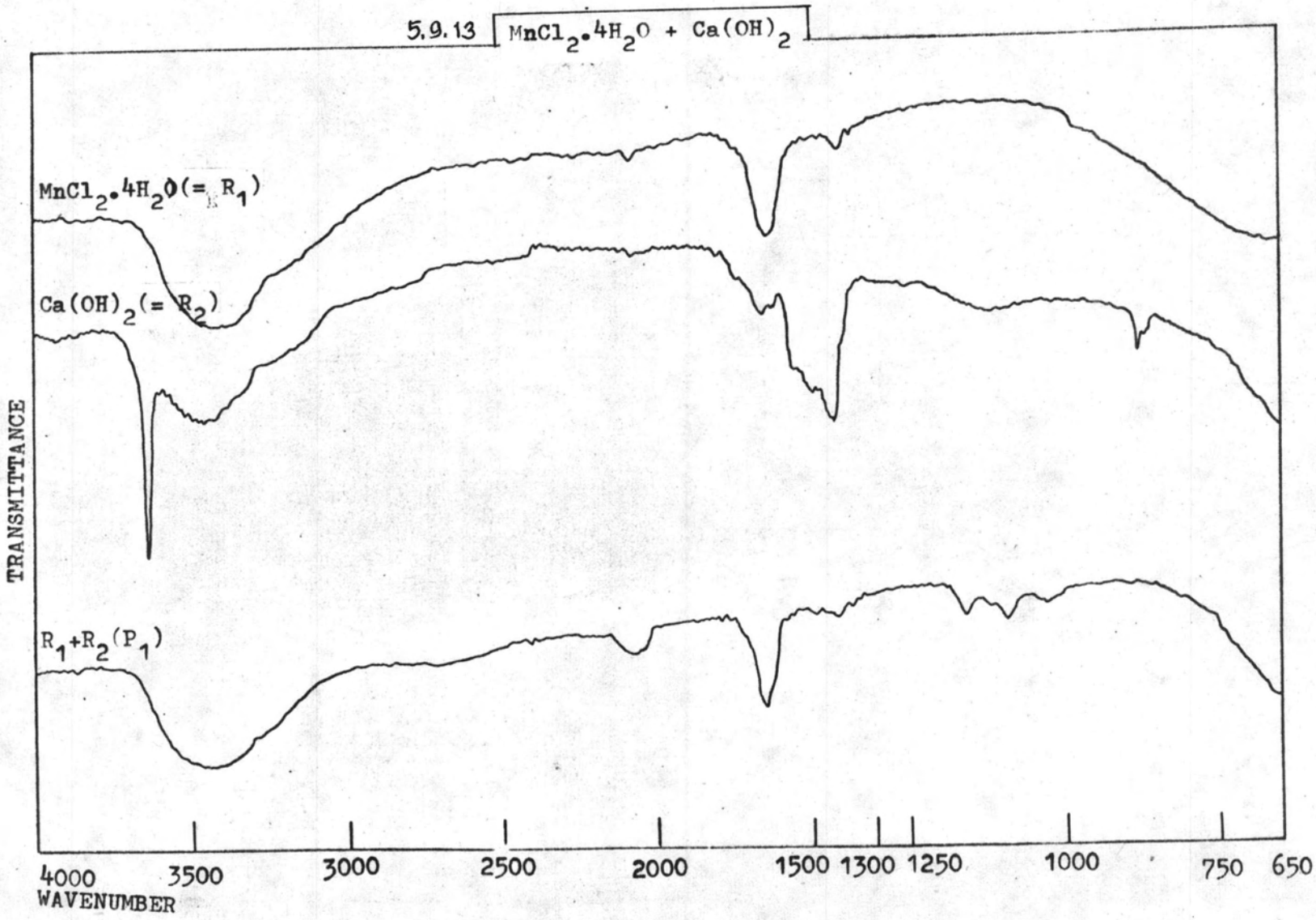
5.9.12 $SnCl_2 \cdot 2H_2O + Bi(NO_3)_3 \cdot 5H_2O$



R_1-white

P_1-yellow

R_2-white

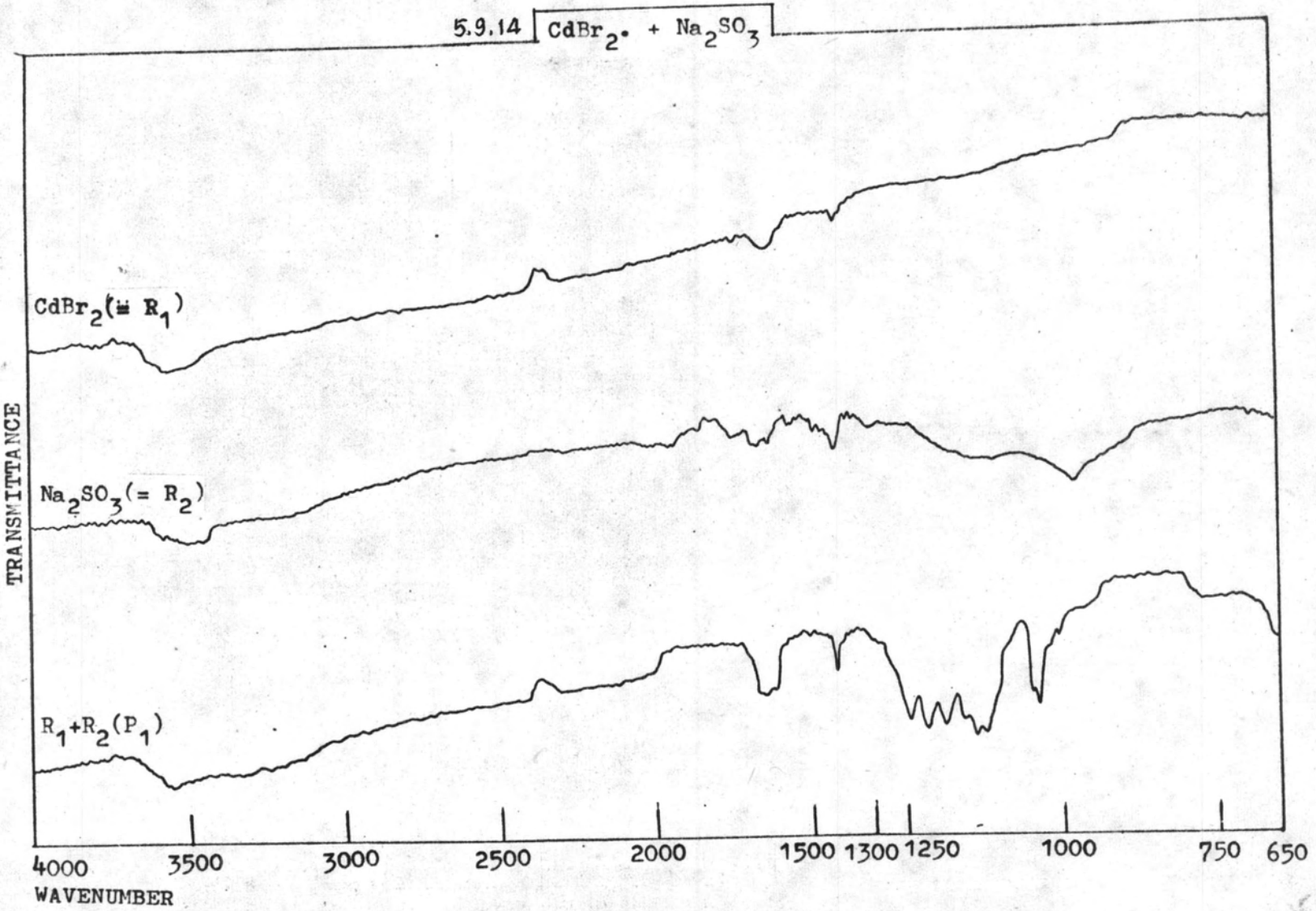


R_1-rose

P_1-black-brown

R_2-white

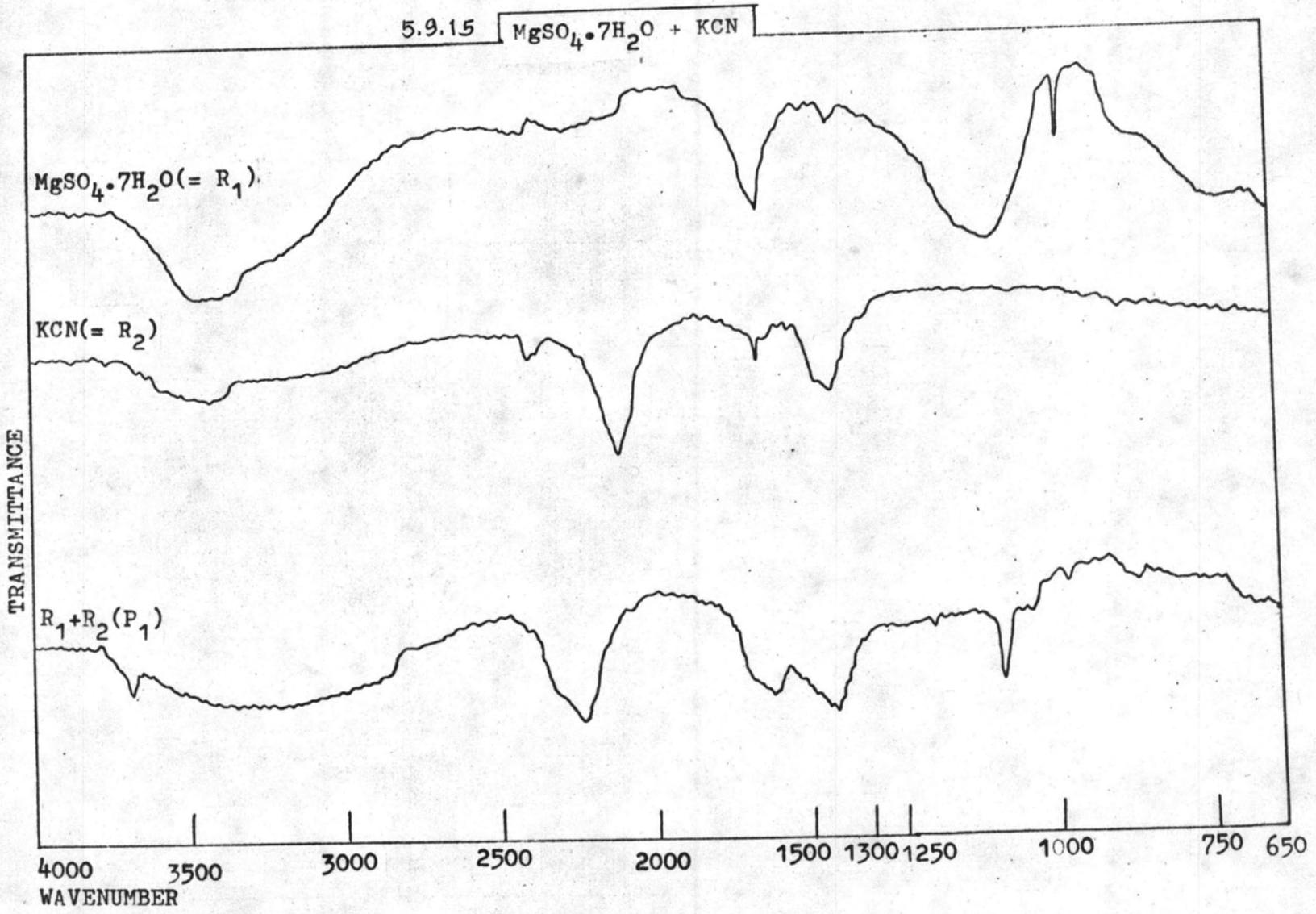
5.9.14 $CdBr_2$ + Na_2SO_3



R_1-white

R_2-white

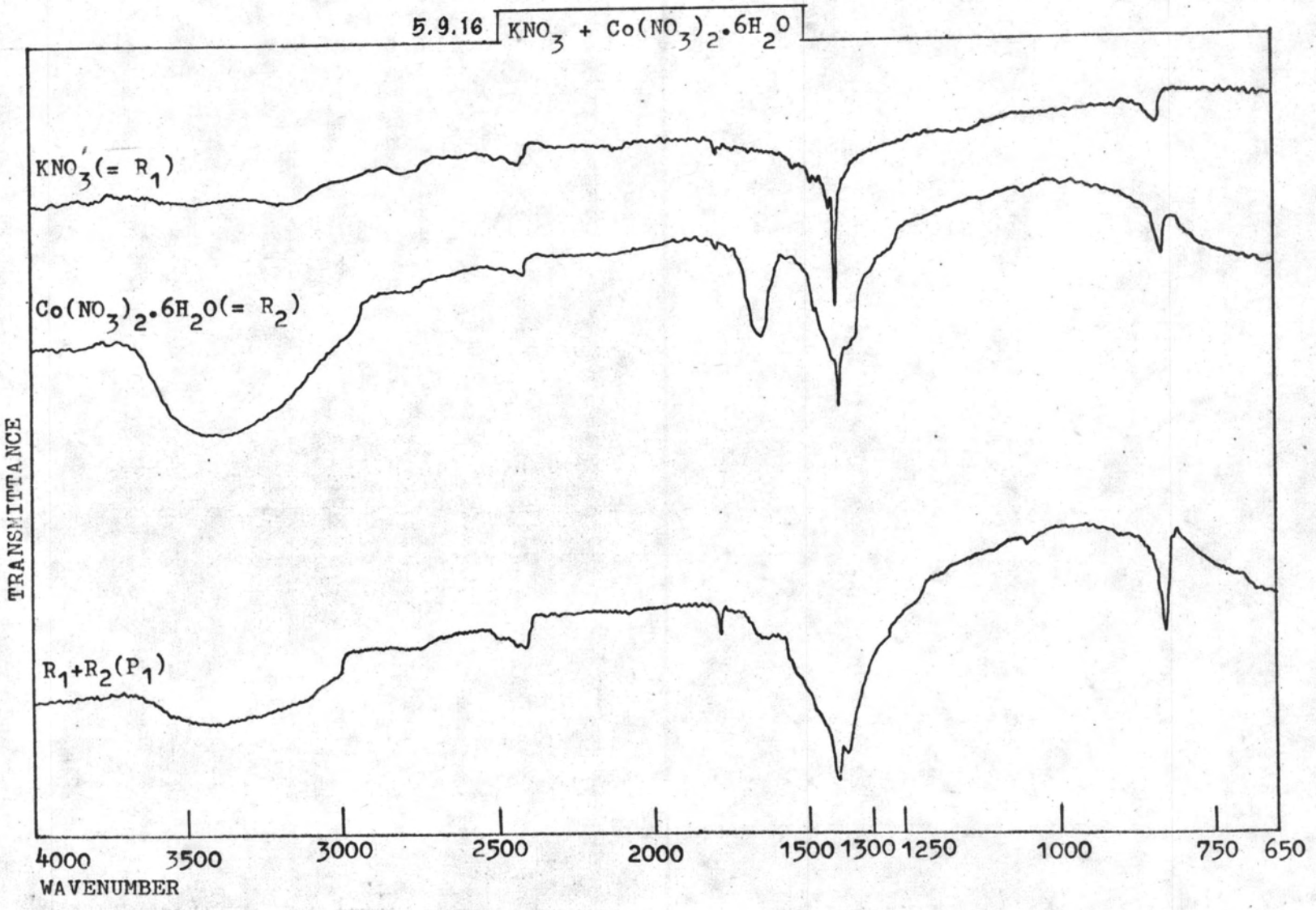
P_1-yellow



R_1-white

P_1-black-brown

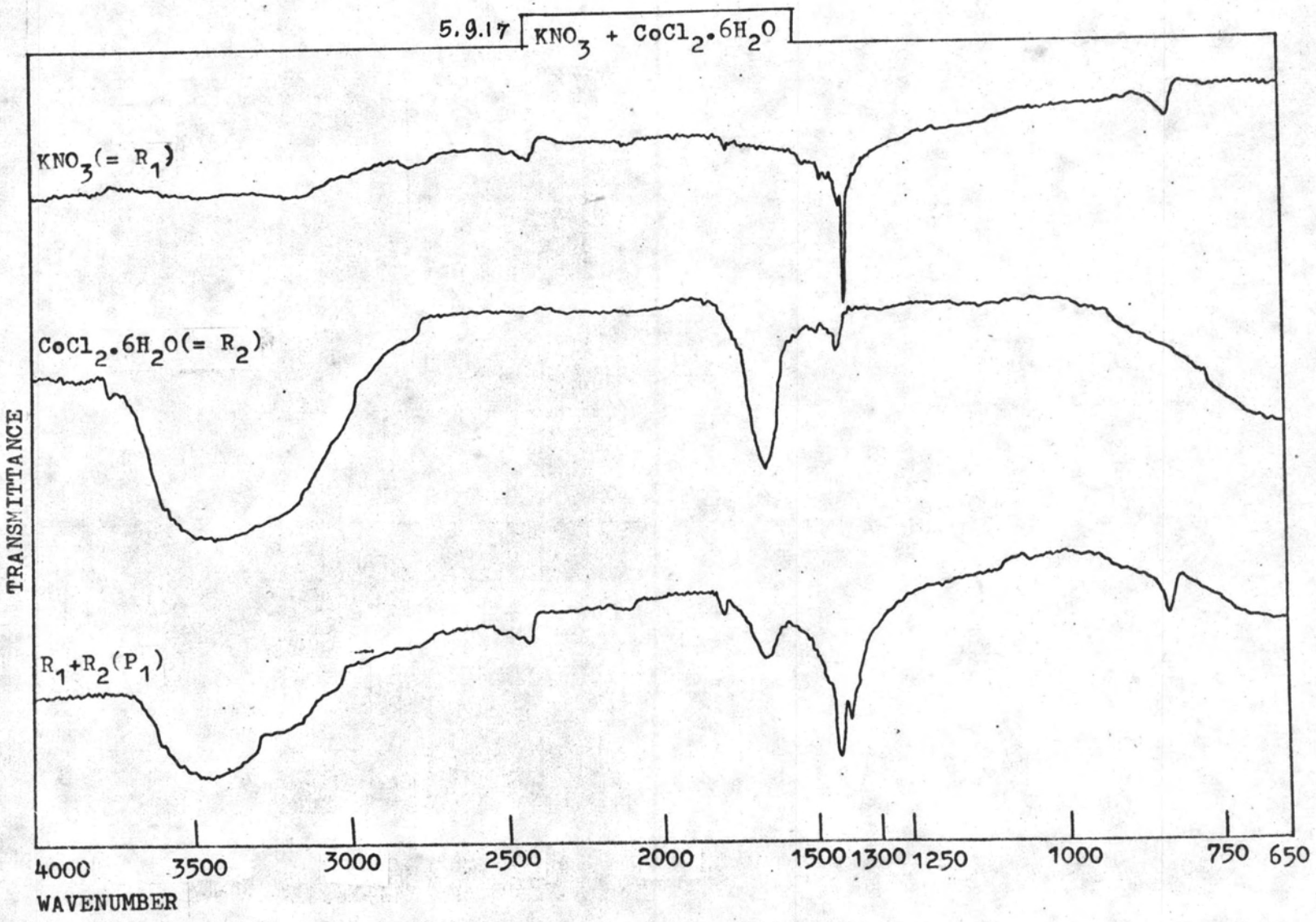
R_2-white



R_1-white

P_1-red-rose

R_2-red

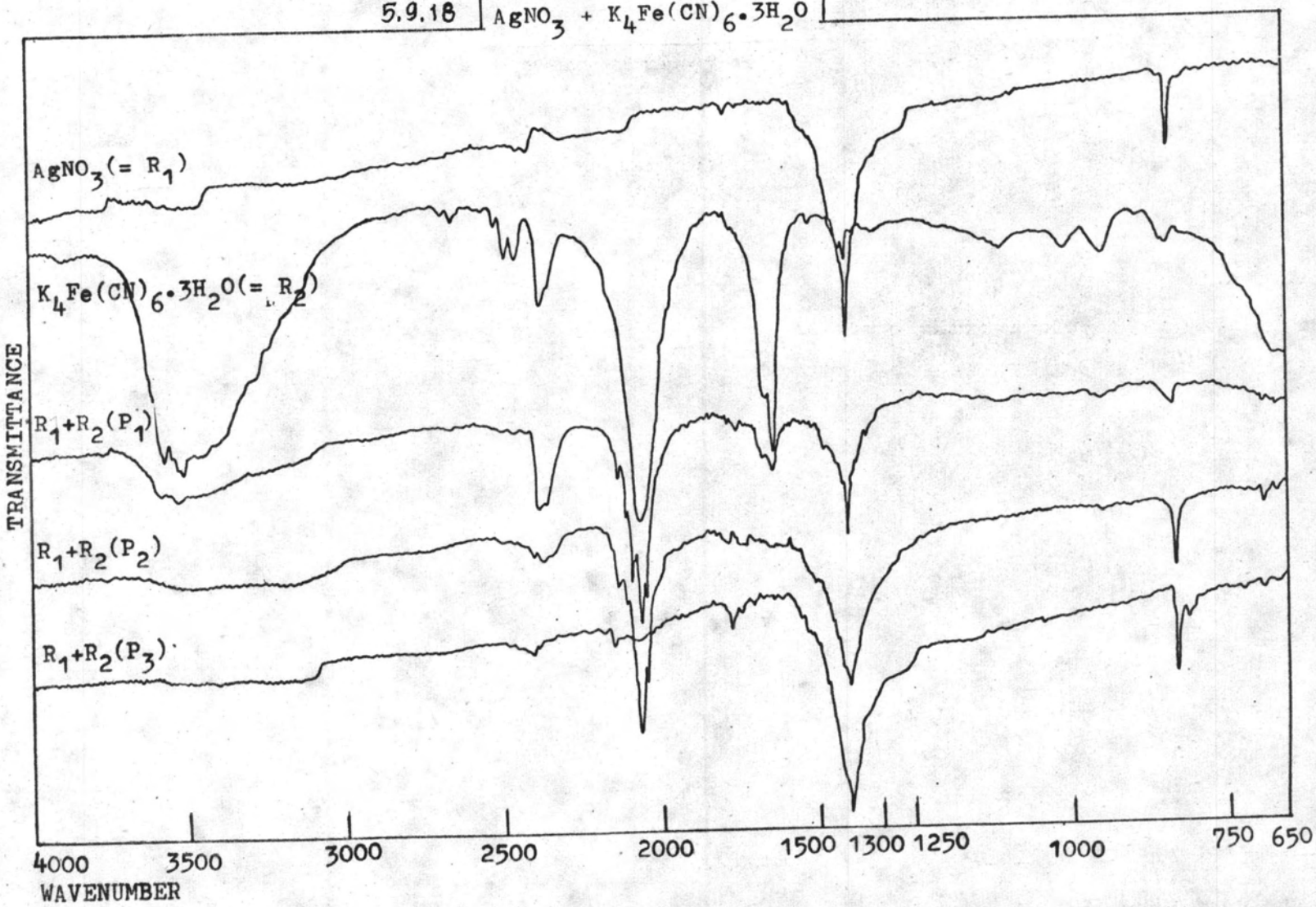


R_1-white

P_1-purple

R_2-red-violet

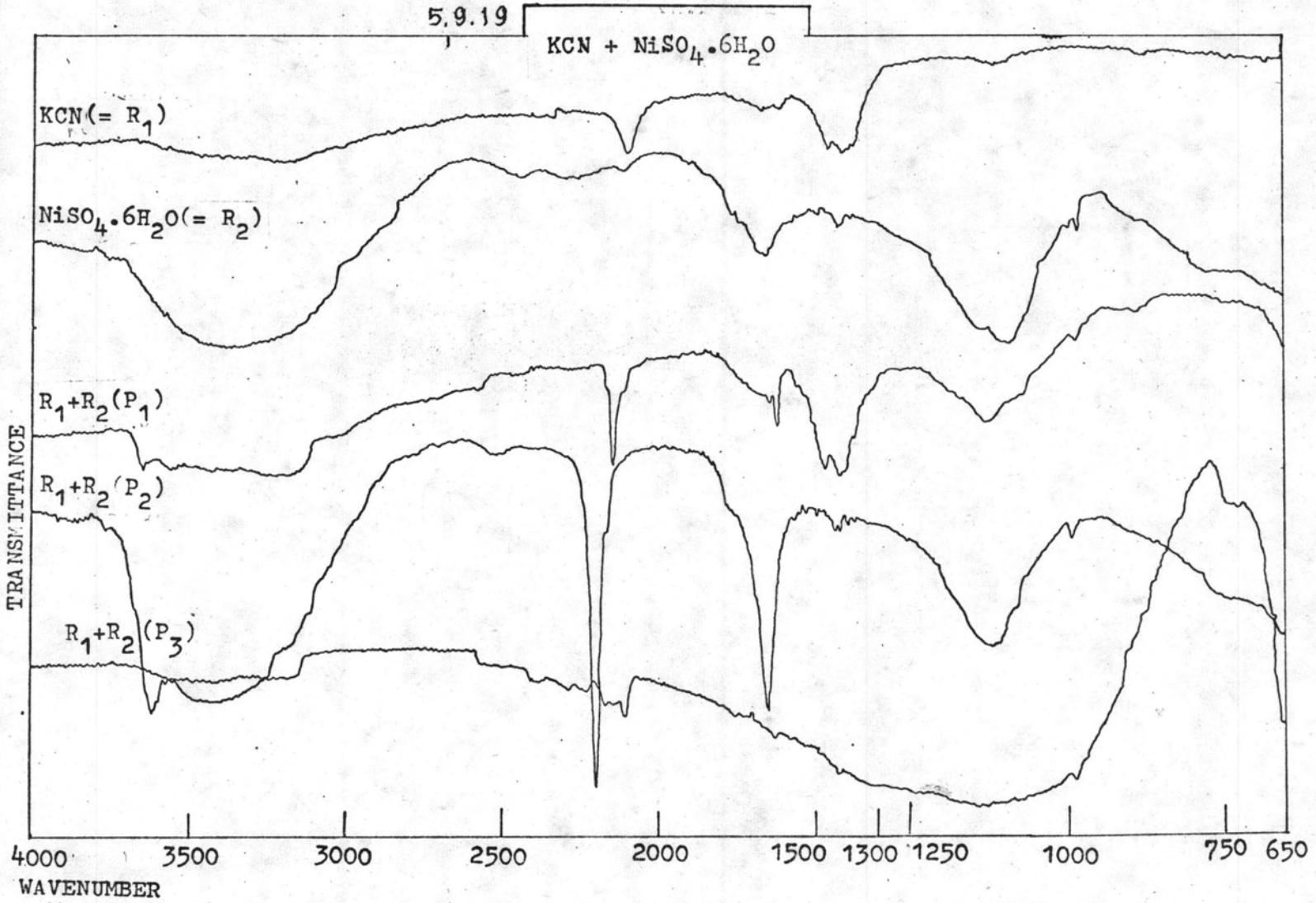
5.9.18 $AgNO_3 + K_4Fe(CN)_6 \cdot 3H_2O$



R_1-white P_1-green P_3-brown

R_2-pale-yellow P_2-blue

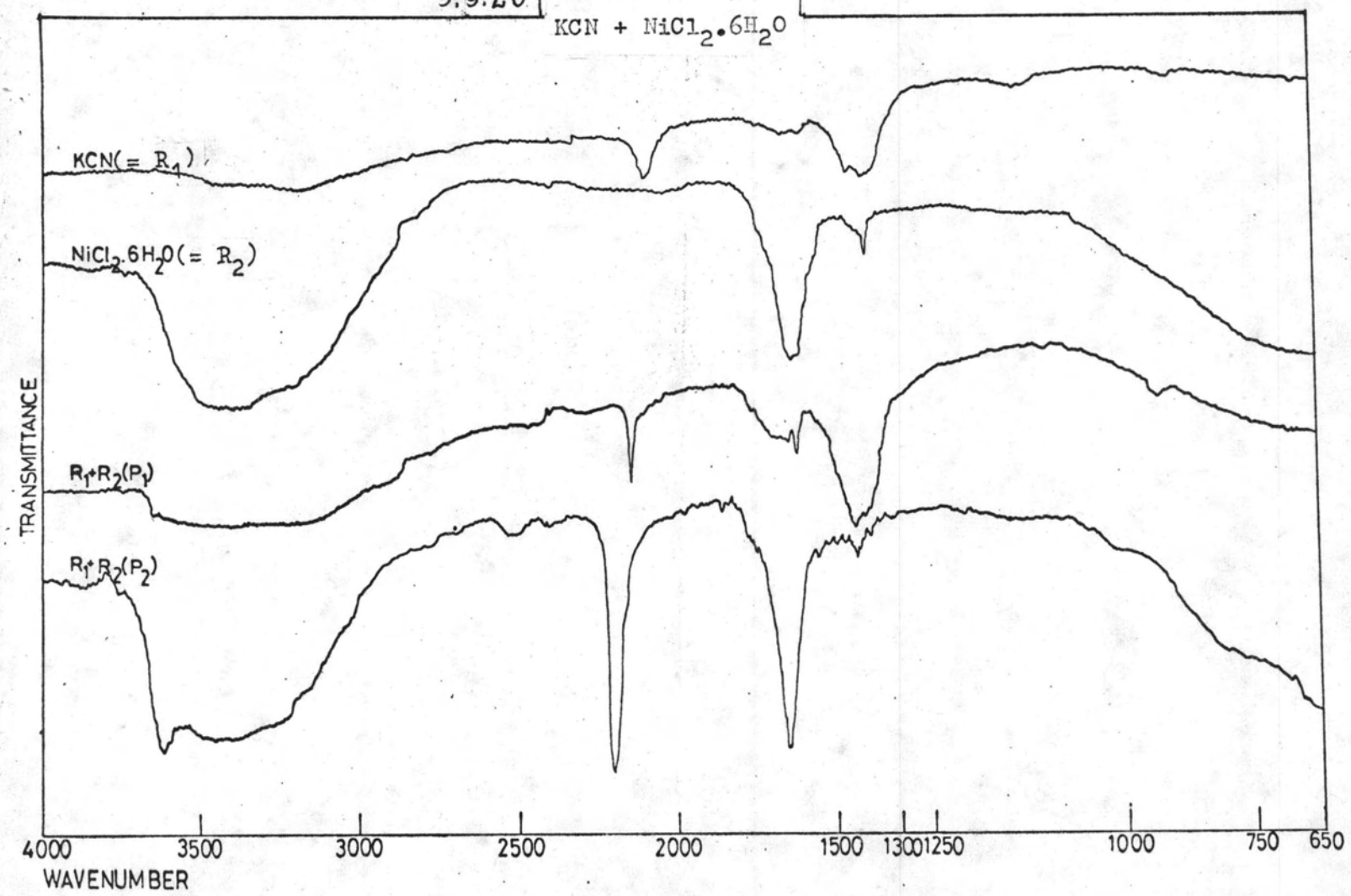
5.9.19



R_1-white P_1-yellow P_3-white

R_2-green P_2-pale blue

5.9.20

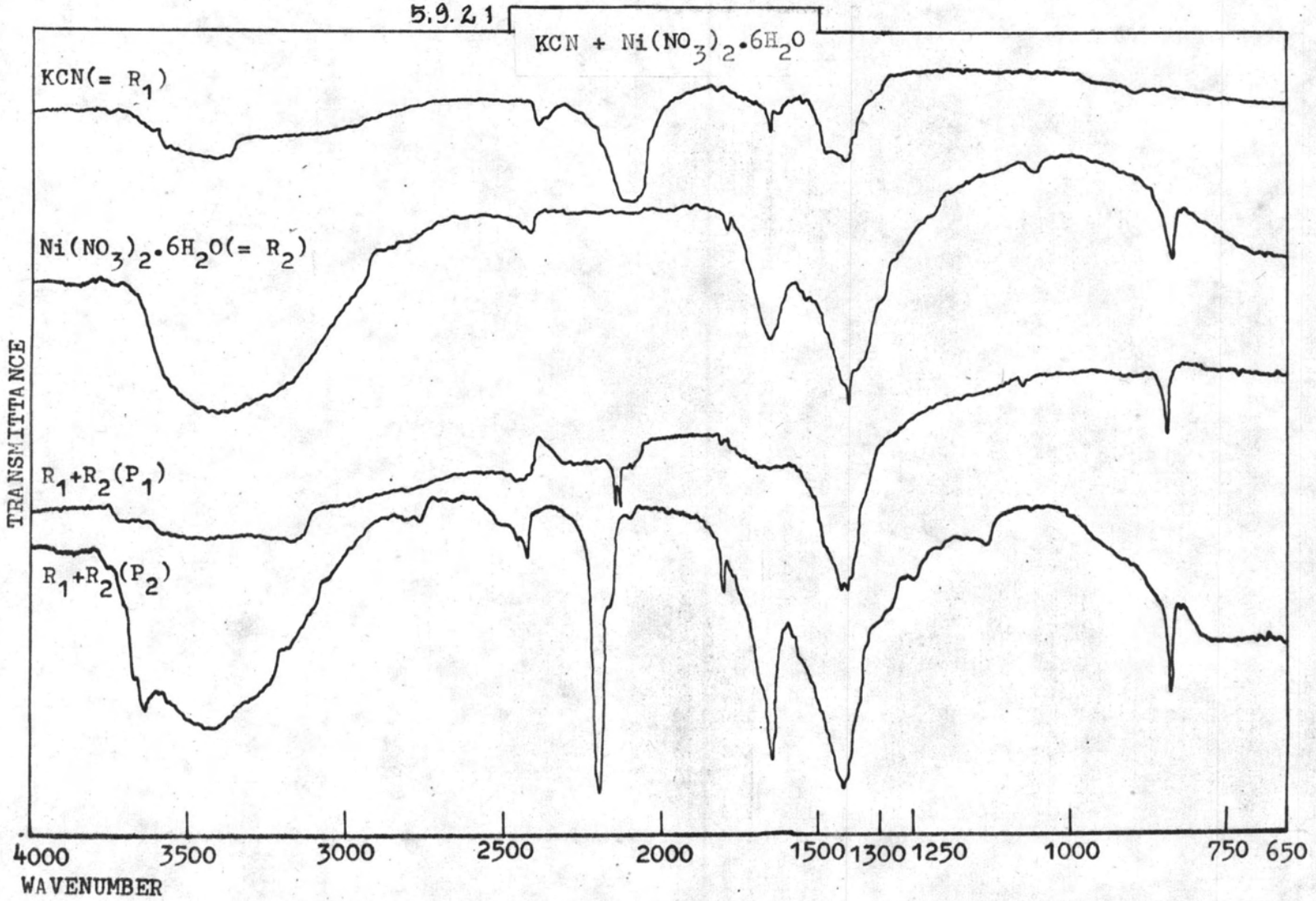


R_1-white

R_2-green

P_1-yellow

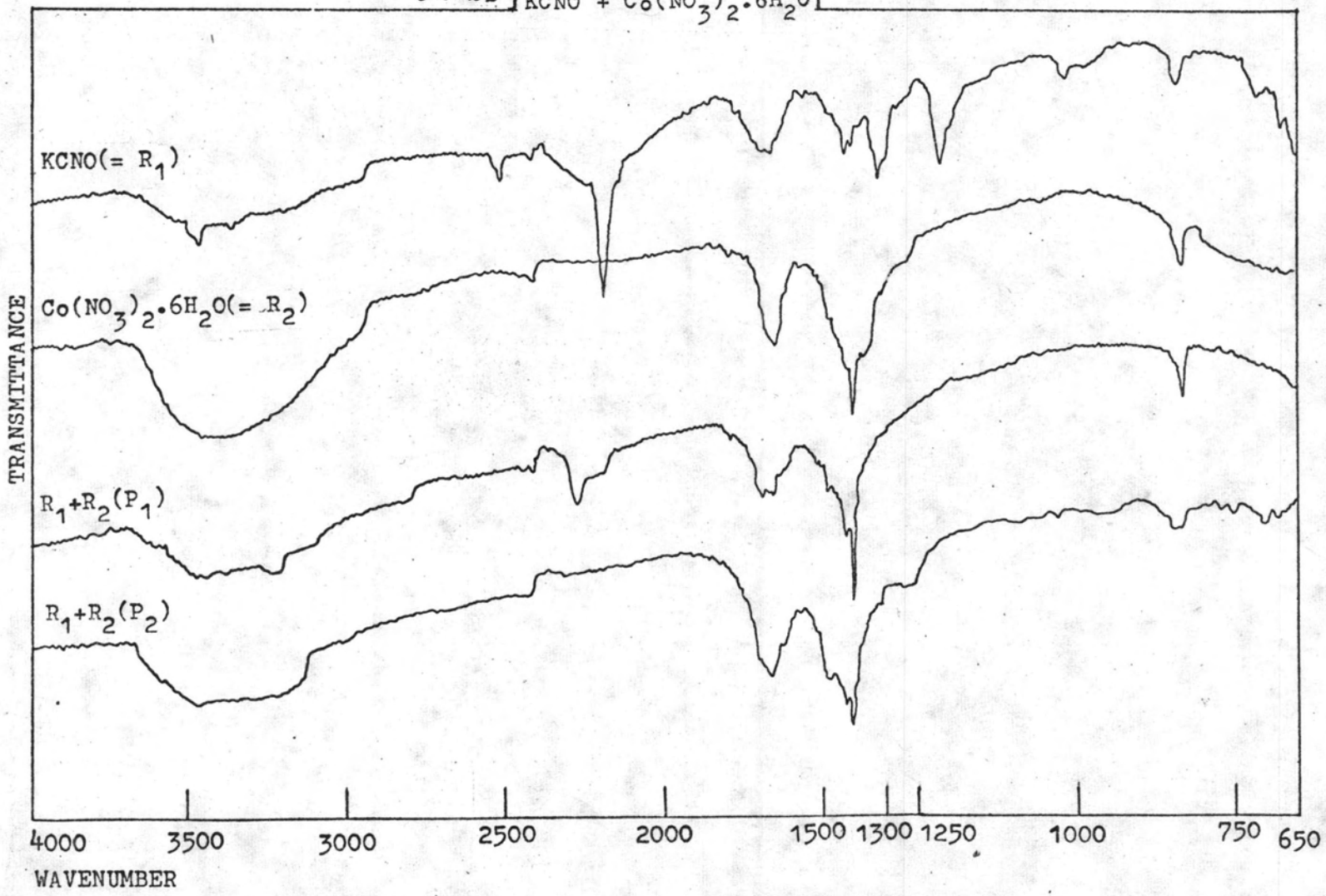
P_2-pale blue



R_1-white P_1-yellow

R_2-green P_2-pale blue

5.9.22 KCNO + $Co(NO_3)_2 \cdot 6H_2O$

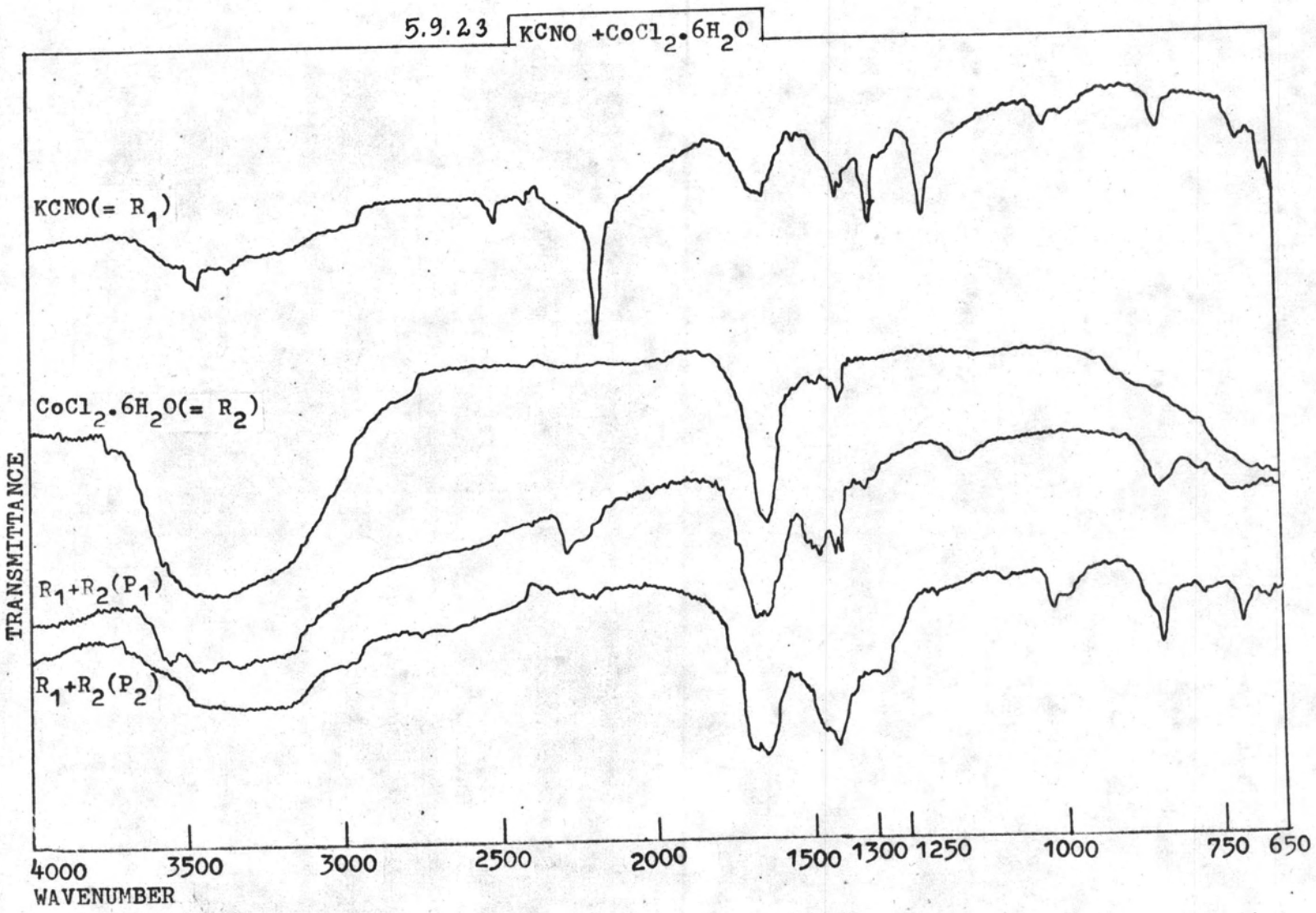


R_1-white

P_1-red-brown

R_2-red

P_2-blue-violet

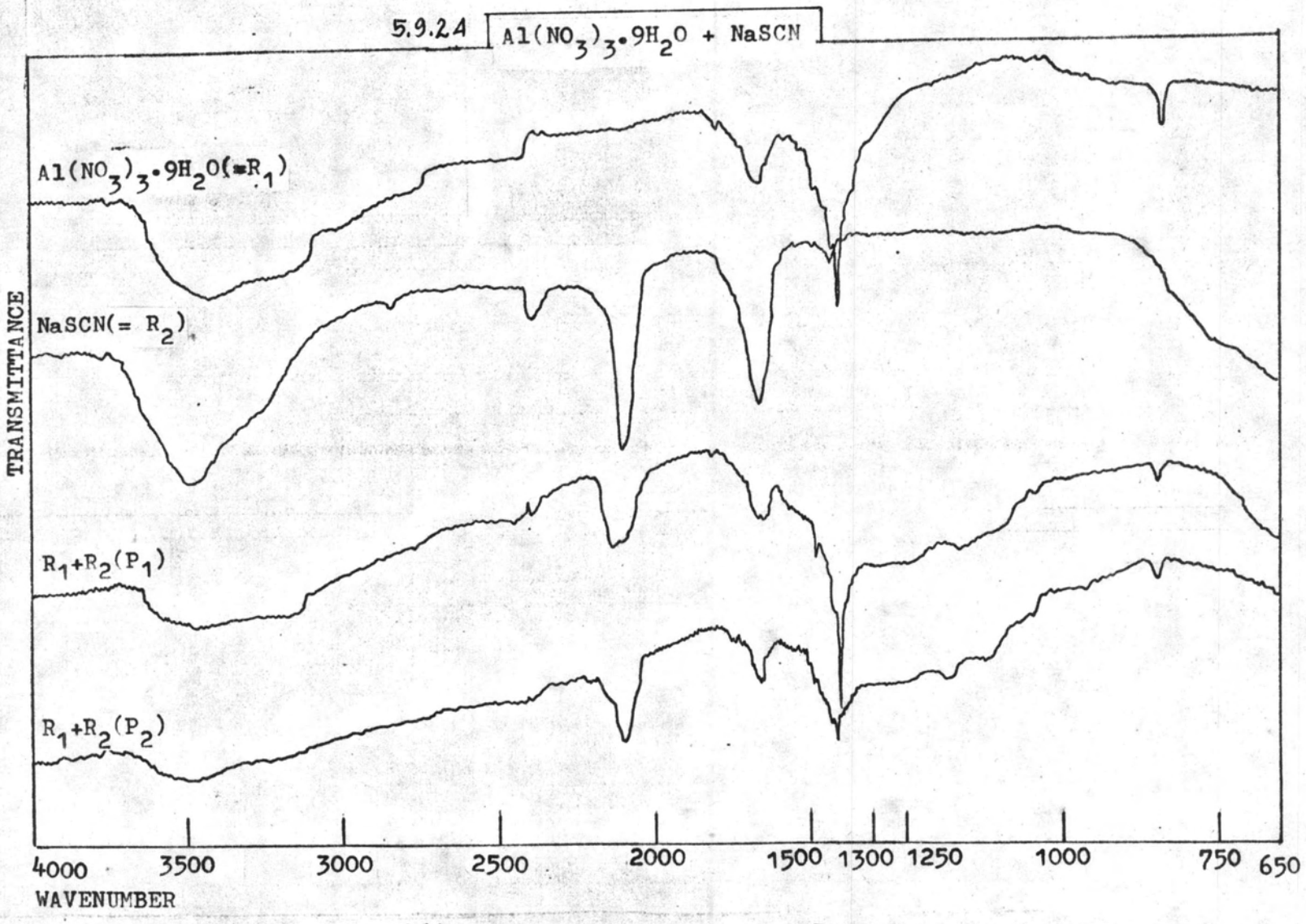


R_1-white

P_1-red

R_2-red-violet

P_2-violet



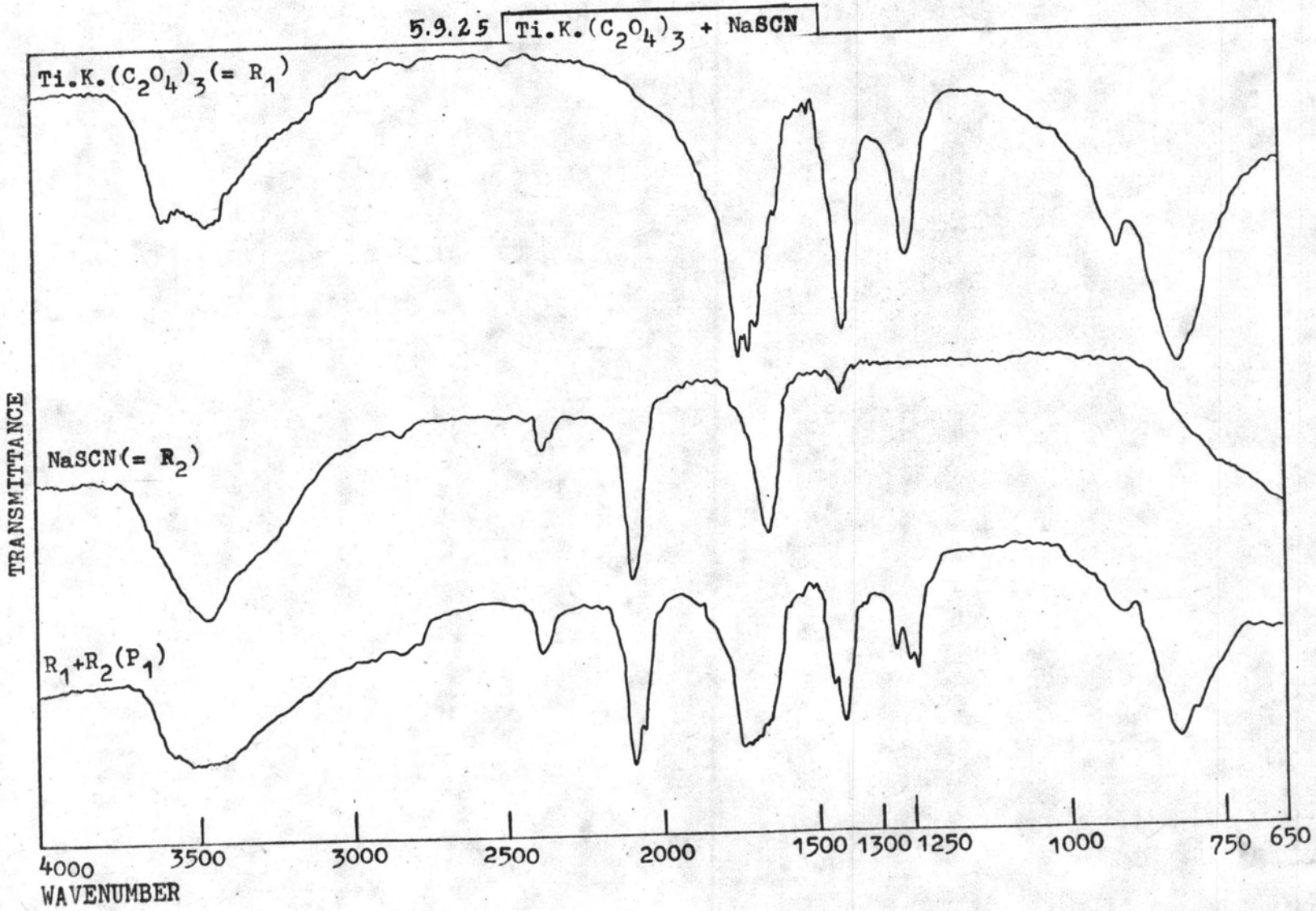
R_1-white

P_1-red-orange

R_2-white

P_2-yellow-orange

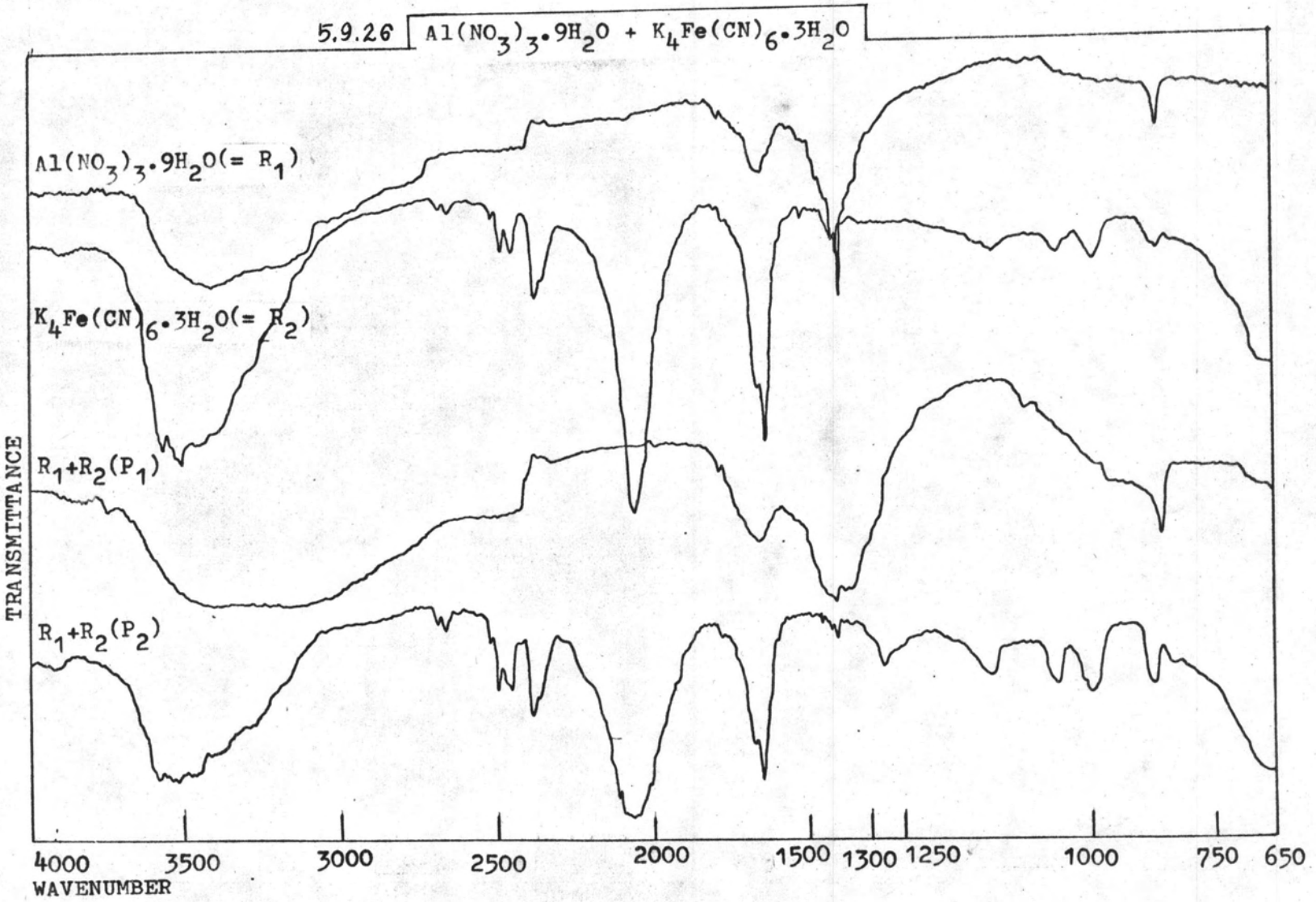
5.9.25 $Ti.K.(C_2O_4)_3$ + NaSCN



R_1-white

P_1-pale-yellow

R_2-white



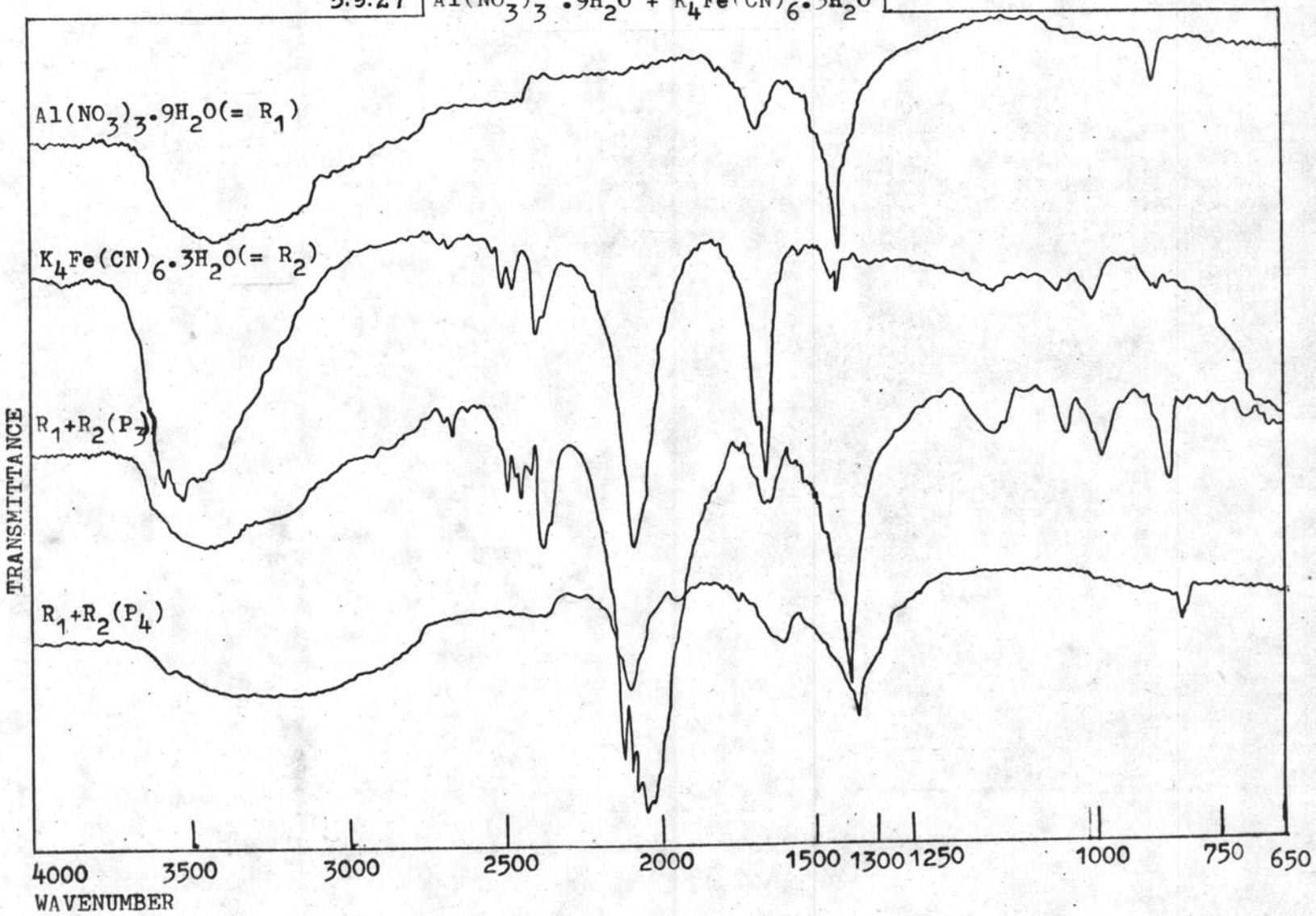
R_1-white

P_1-pale-blue

R_2-pale-yellow

P_2-green-yellow

5.9.27 $Al(NO_3)_3 \cdot 9H_2O + K_4Fe(CN)_6 \cdot 3H_2O$

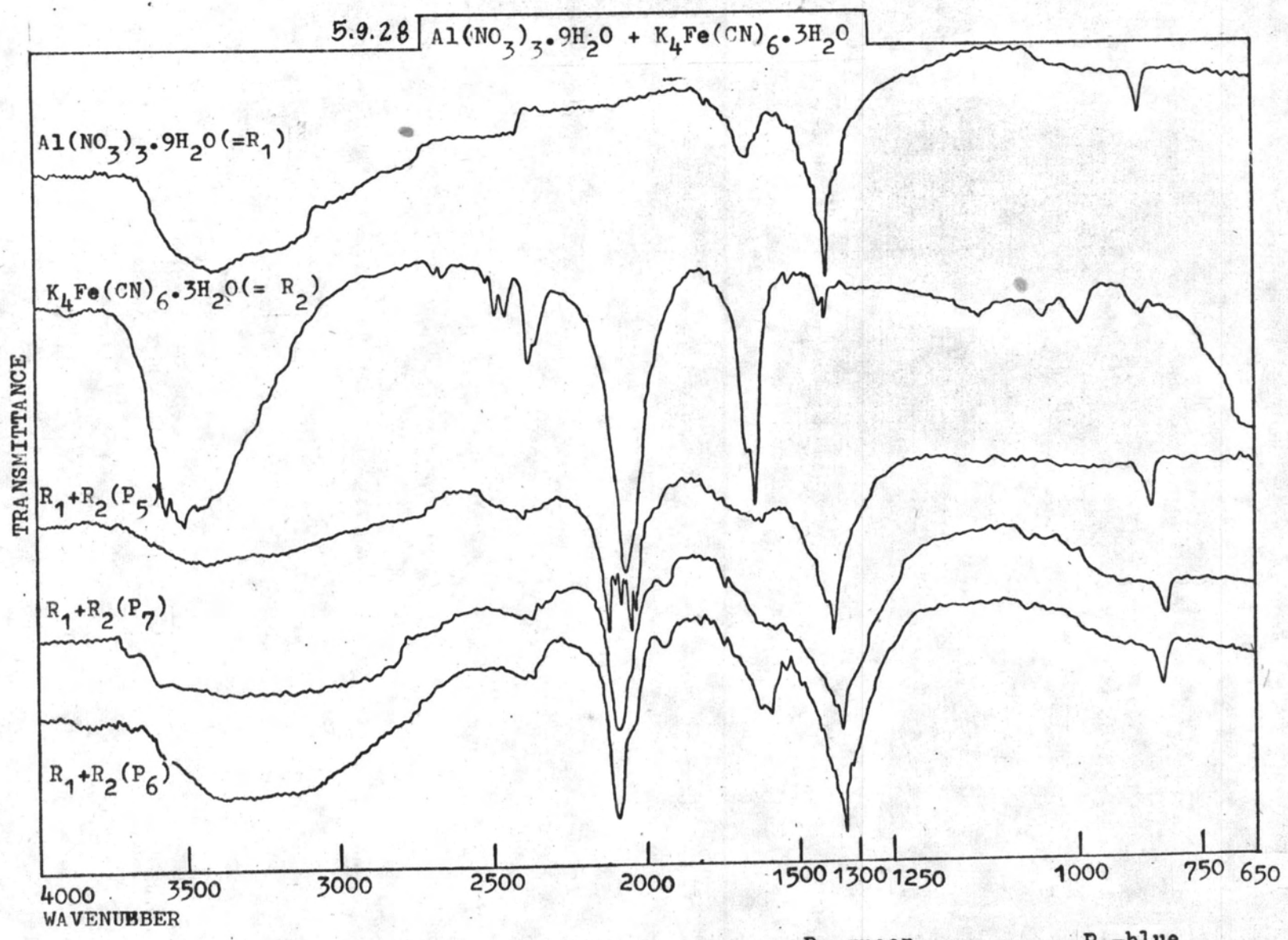


R_1-white

R_2-pale-yellow

P_3-yellow-green

P_4-dark-green



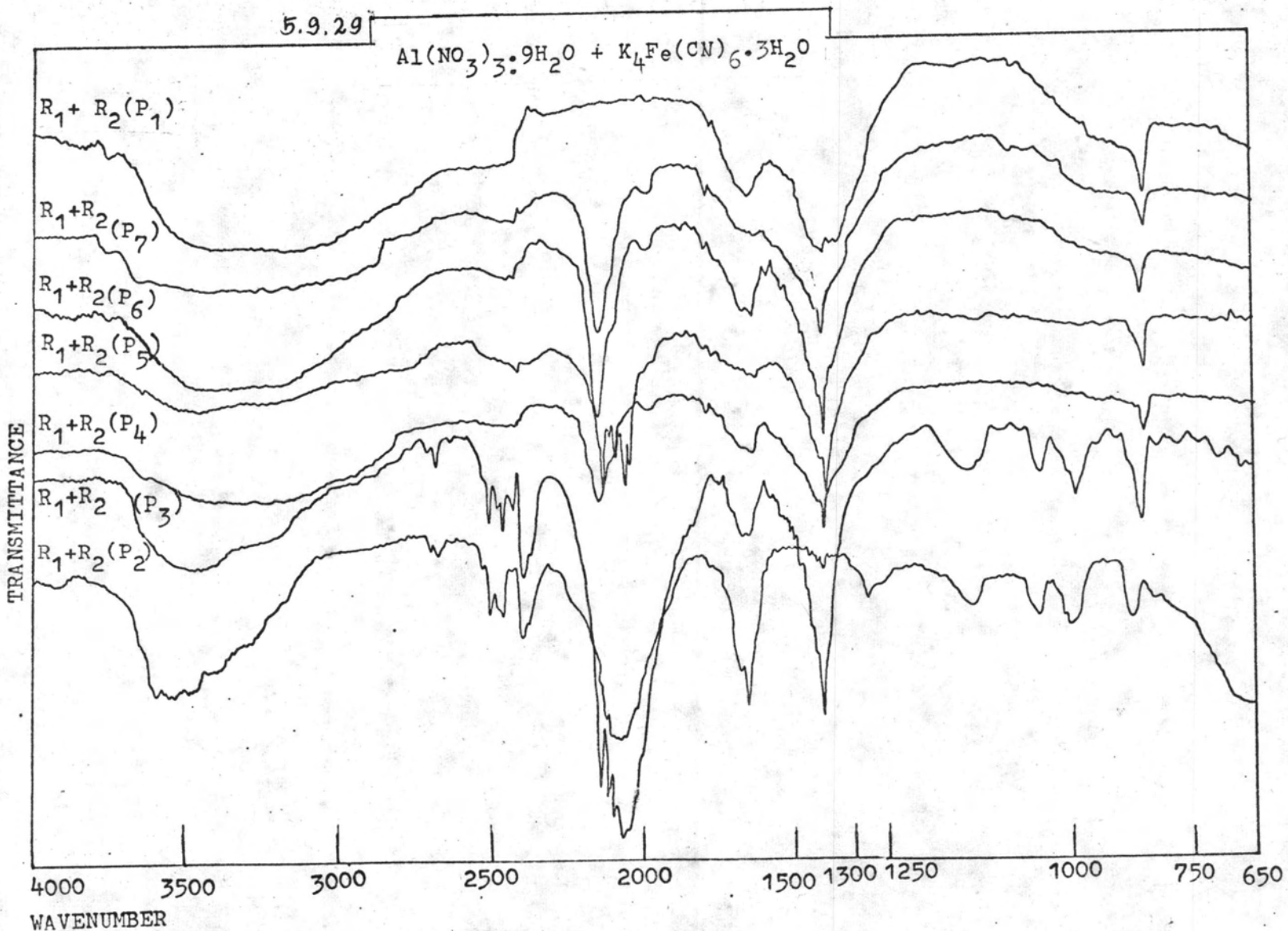
R_1-white

P_5-green

P_7-blue

R_2-pale-yellow

P_6-green-blue



P_1-pale-blue P_3-yellow-green P_5-green P_7-blue

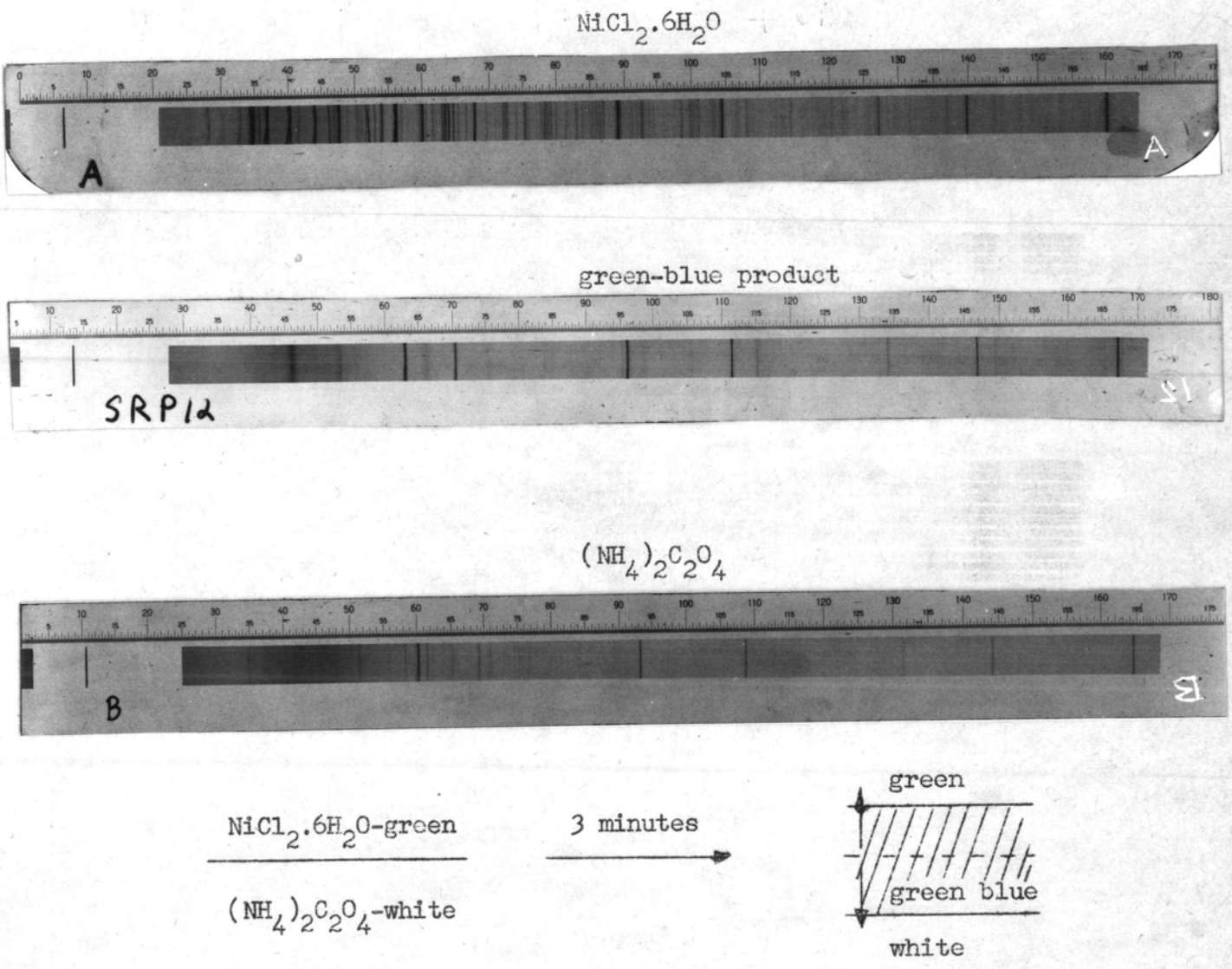
P_2-green-yellow P_4-dark-green P_6-green-blue

5.5 Structural investigation of solid - solid reaction product by X-ray powder method.

The X-ray diffraction patterns by powder method of both reactants and products of the same system were compared to show the pattern difference since the X-ray pattern resulted from the characteristic structure of compound. The existence of a dark line on the film satisfied the Bragg relation. An X-ray diffraction pattern obtained by this method enables a series of values of θ for which the Bragg relation $2d \sin \theta = n \lambda$ is obeyed where d is interplanar distance, θ is Bragg's angle, λ is X-ray's wavelength. These may be used to determine the unit cell dimensions, a, b and c, of simple or known crystal. The determination of size and shape of unknown complex unit cells is possible in principle, but in practice results are doubtful since it may not be possible to make measurements with sufficient accuracy to distinguish between alternative possibilities. The more complex cells yield numerous diffraction on the film from which the determination of all the lattice parameters may be very difficult.

Further examination by other X-ray techniques might give much more information about structure and composition of interesting complex and also support the mechanism interpretation of any particular reaction, while the pattern obtained in a moment only displayed the confirmation of new production from solid - solid reaction.

5.10.1 $NiCl_2.6H_2O + (NH_4)_2C_2O_4$



$NiCl_2.6H_2O$-green

$(NH_4)_2C_2O_4$-white

3 minutes ⟶

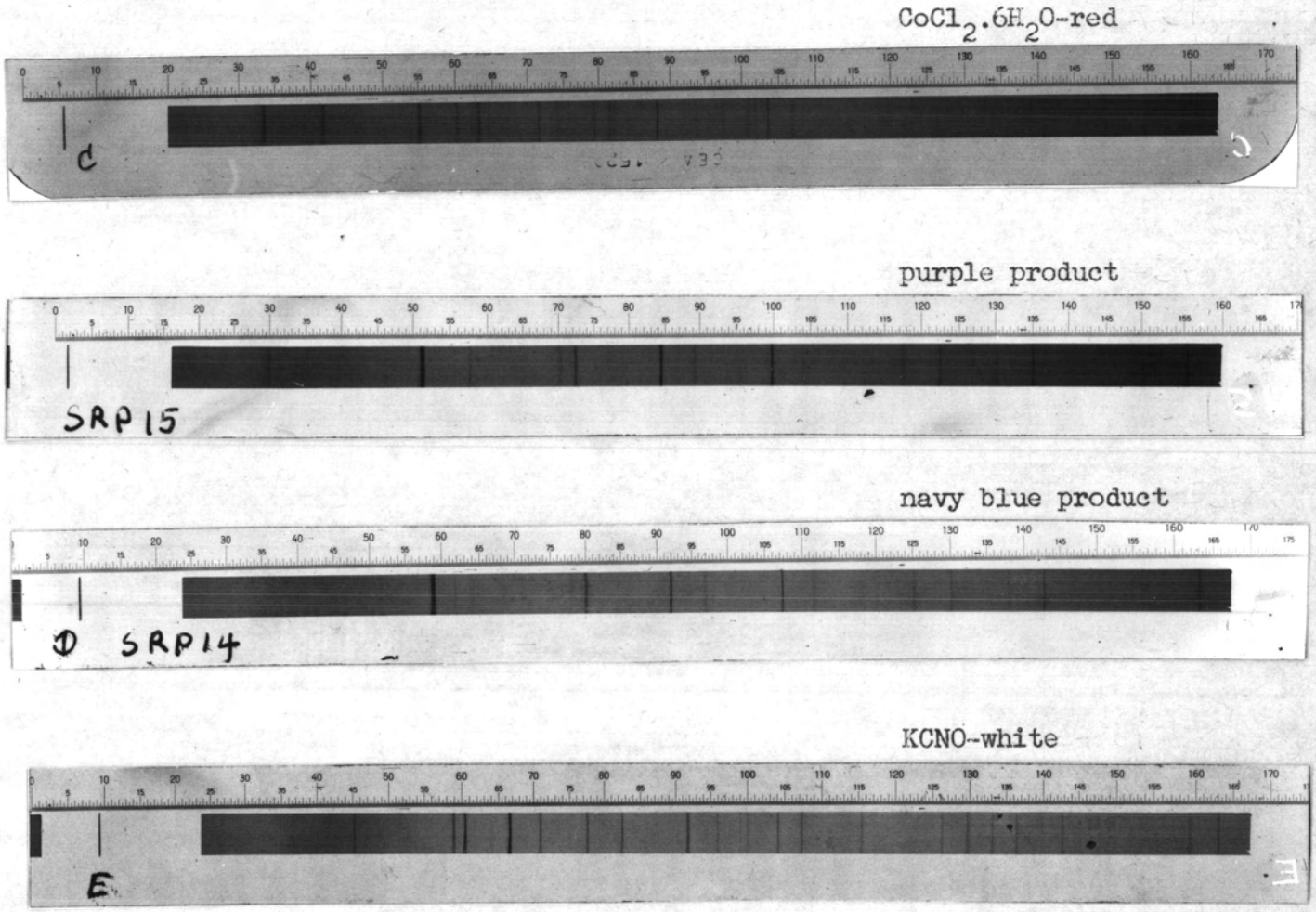
green

green blue

white

Fig 5.10 X-ray powder pattern of reactant and product of solid-solid reaction. (mixed with Si)

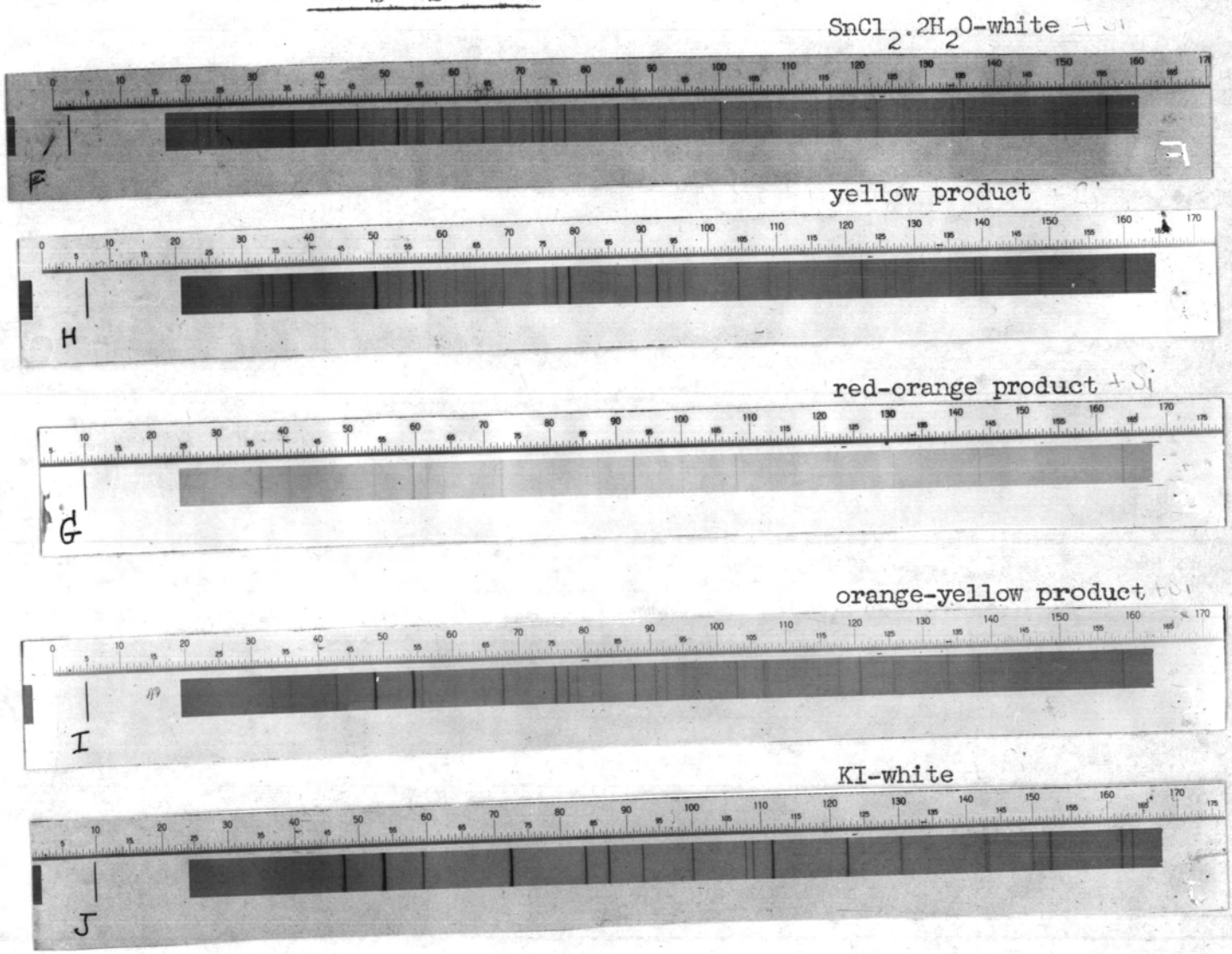
5.10.2 $CoCl_2.6H_2O$ + KCNO



$CoCl_2.6H_2O$-red
KCNO-white
—immediately→ red navy blue white
—5 minutes→ red purple / navy blue white

Fig 5.10 X-ray powder pattern of reactant and product of solid-solid reaction. (mixed with Si)

5.10.3 $SnCl_2.2H_2O$ + KI



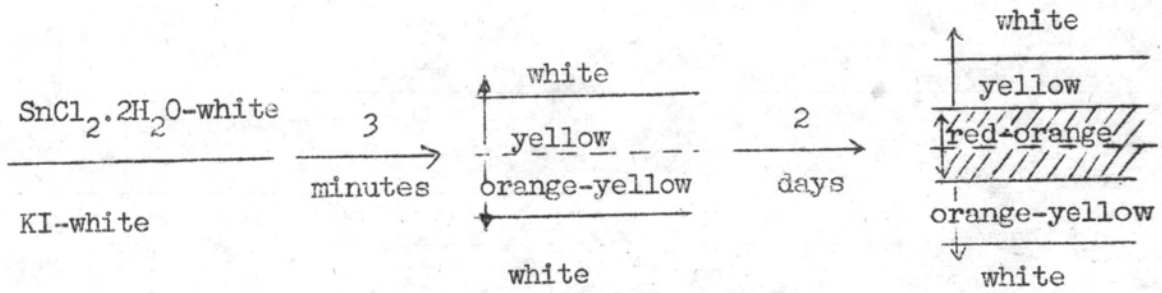
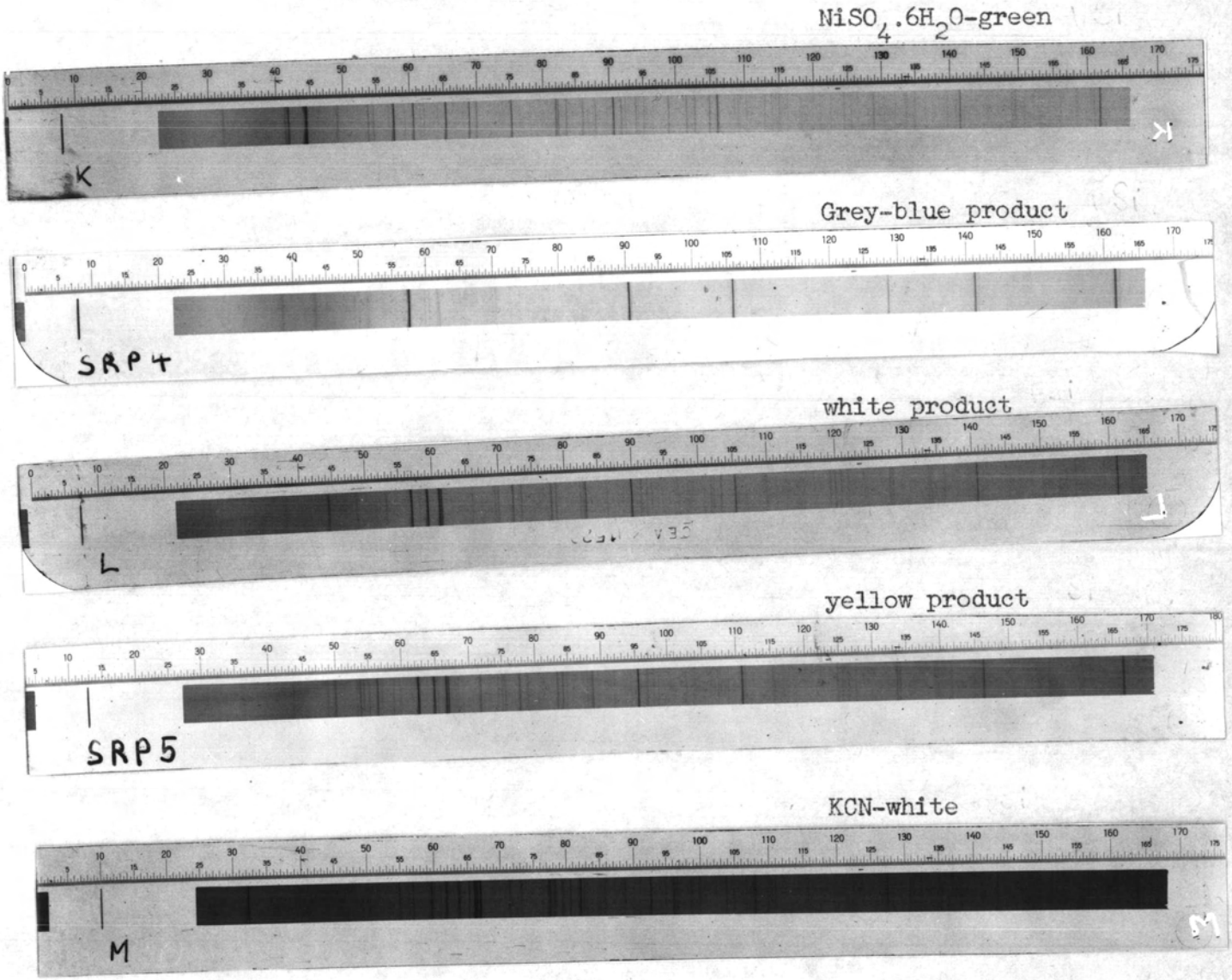


Fig 5.10 X-ray powder pattern of reactant and product of solid-solid reaction. (mixed with Si)

5.10.4 $NiSO_4.6H_2O$ + KCN



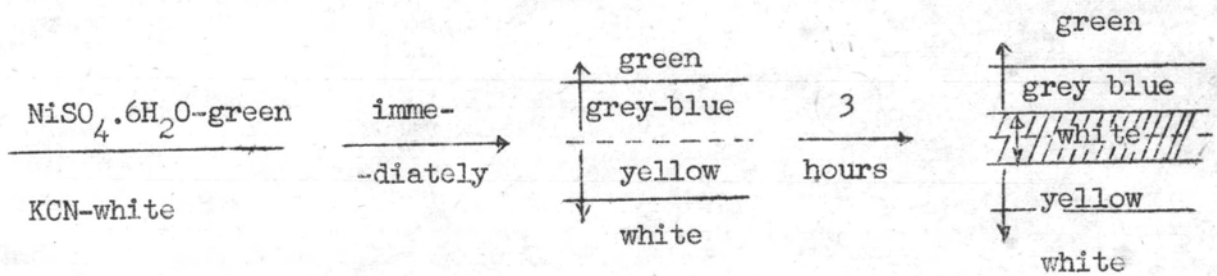
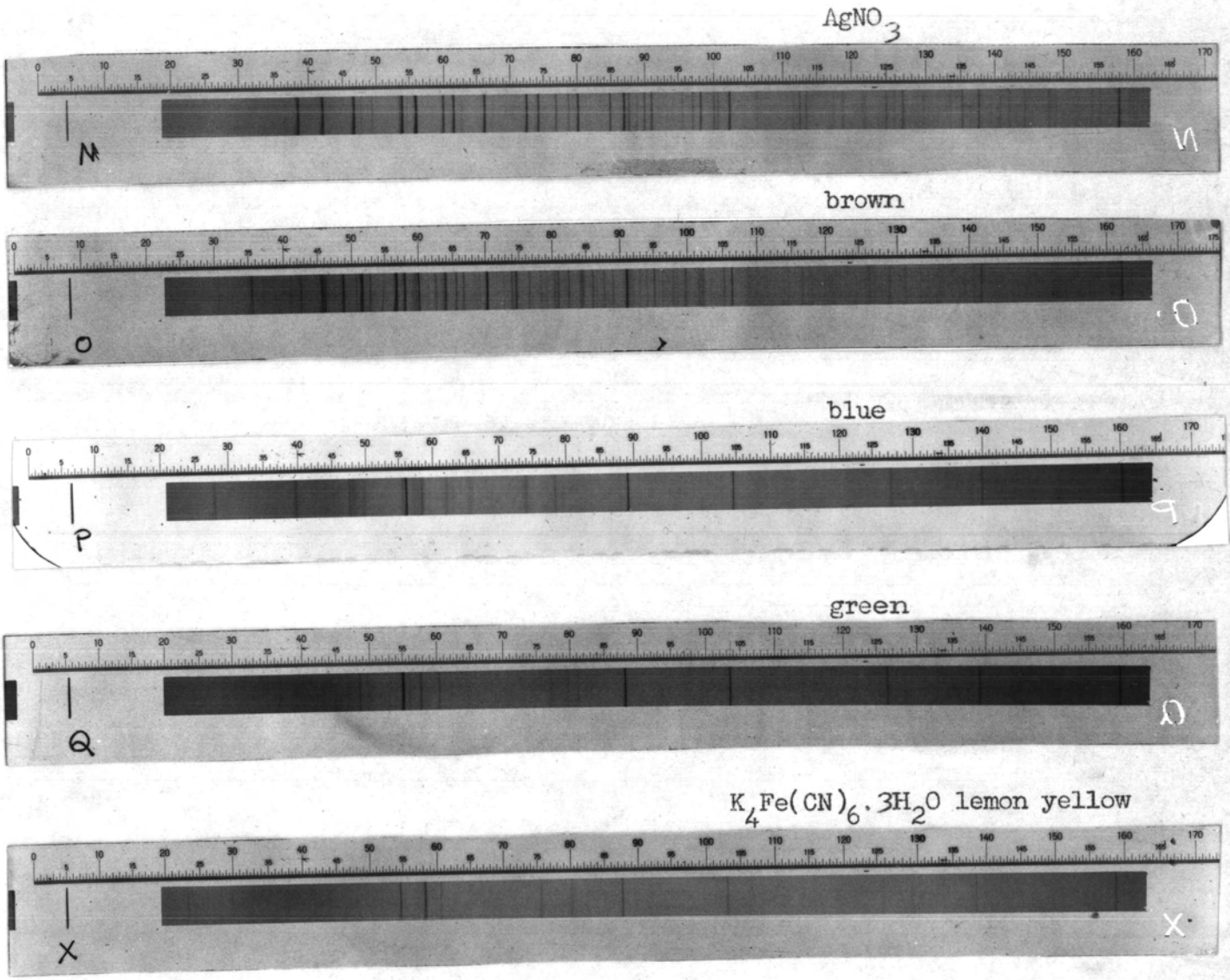


Fig 5.10 X-ray powder pattern of reactant and product of solid-solid reaction. (mixed with Si)

5.10.5 $AgNO_3 + K_4Fe(CN)_4.3H_2O$



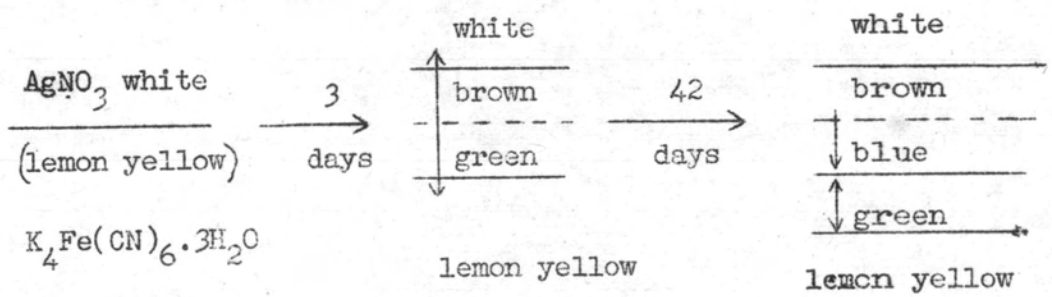
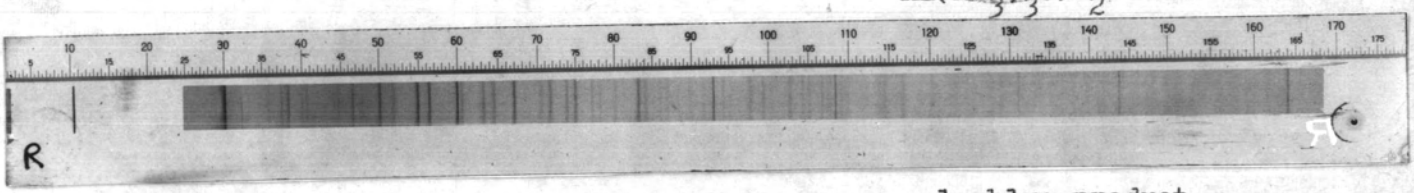


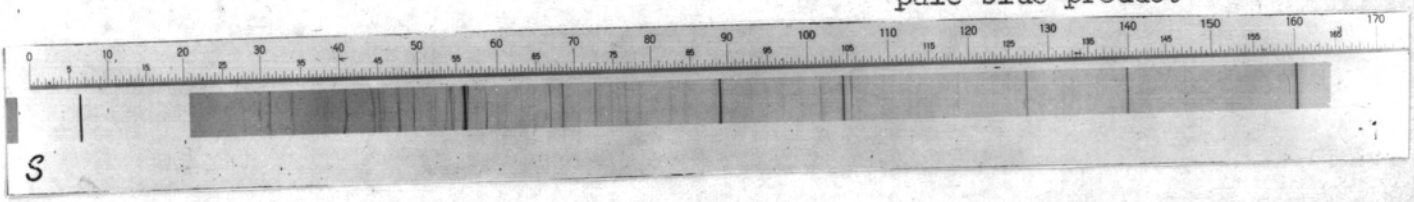
Fig 5.10 X-ray powder pattern of reactant and product of solid-solid reaction. (mixed with Si)

5.10.6 $Al(NO_3)_3 \cdot 9H_2O + K_4Fe(CN)_6 \cdot 3H_2O$

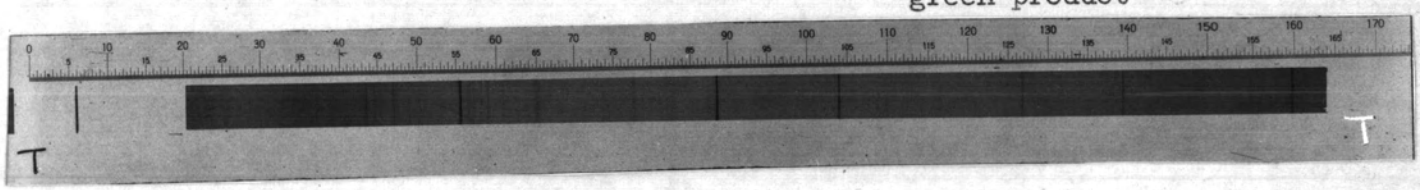
$Al(NO_3)_3 \cdot 9H_2O$-white



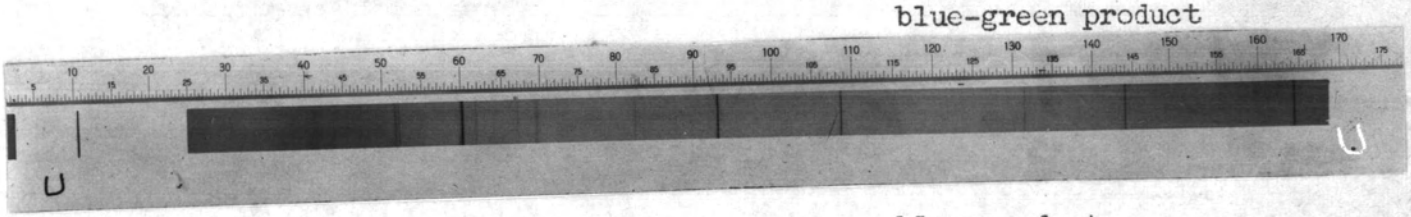
pale blue product



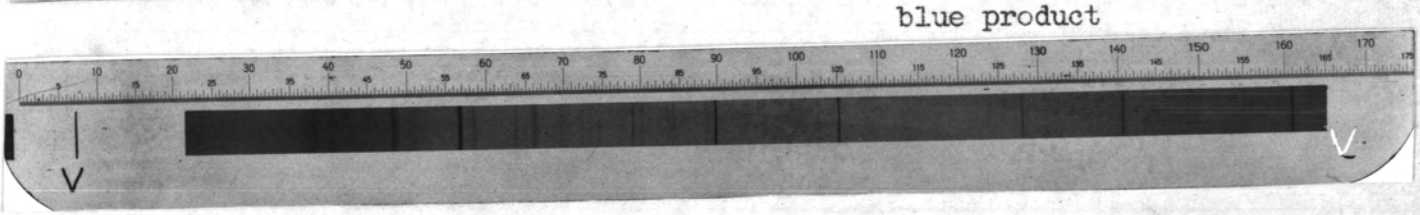
green product



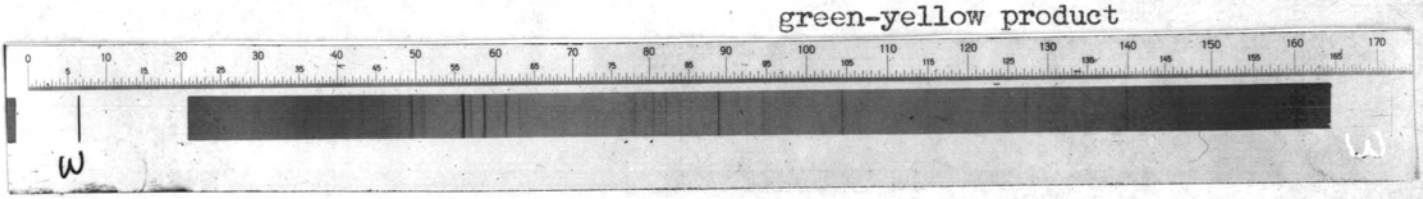
blue-green product



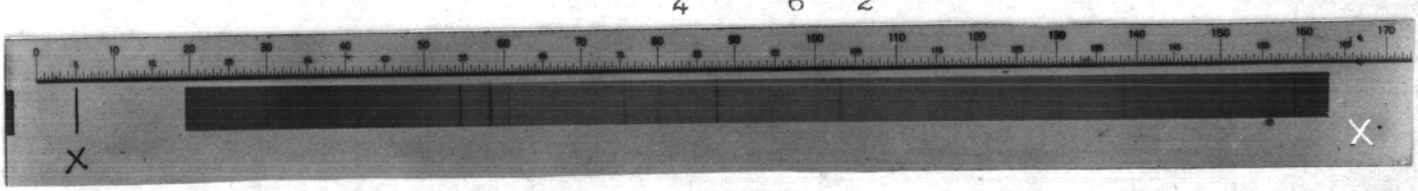
blue product



green-yellow product



$K_4Fe(CN)_6 \cdot 3H_2O$-lemon yellow

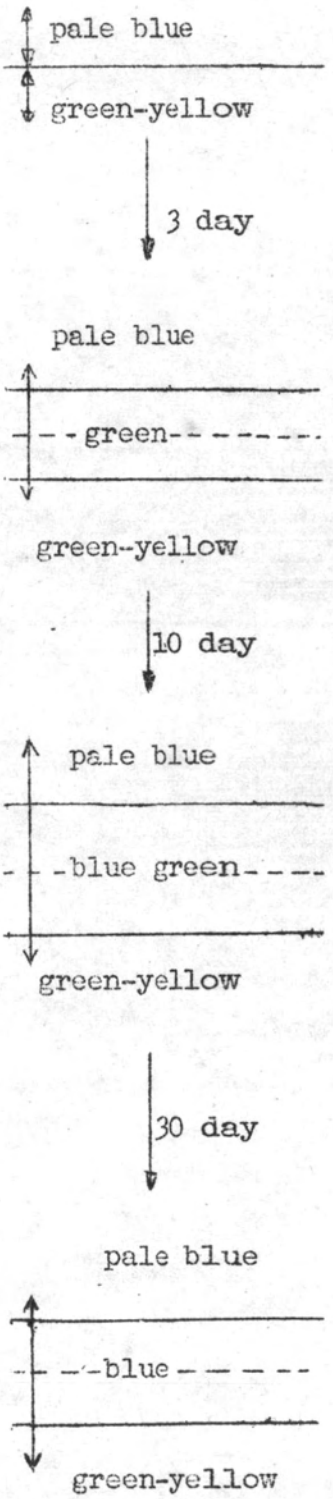


$Al(NO_3)_3 \cdot 9H_2O$ - white

(lemon yellow)

$K_4Fe(CN)_6$ - lemon yellow

1 hour →



5.6 The conductivity measurement of both inorganic compound and solid - solid reaction.

5.6.1 The conductivity measurement of inorganic compound.

The conductivity of inorganic compound could be measured in solid state by measuring current at variable applied voltage. The conductivity of such compound at given time was related to the current per applied voltage.

The results which showed the relationship between appeared current and applied voltage of such compound, could be presented and concluded as in the following data and figures.

Table 5.11 Conductivity measurement of inorganic compound.

.KCN		KCNO		$Ni(NO_3)_2.6H_2O$	
26.2°C thickness 2.032 mm.		25.4°C thickness 1.760 mm.		25.4°C thickness 1.850 mm.	
voltage (v)	milliampere (ma)	voltage (v)	microampere (μa)	voltage (v)	milliampere (ma)
0.0	0.00	0.0	0.00	0.0	0.00
2.0	0.30	2.0	10.00	2.0	0.50
4.0	1.00	5.0	26.00	4.0	2.00
6.0	1.80	7.0	37.50	6.0	4.20
8.0	2.70	10.0	56.00	8.0	7.80
10.0	3.80	13.0	70.00	10.0	11.50
12.0	4.70	15.0	82.00	12.0	16.00
14.0	5.60	18.0	95.00	14.0	23.00
16.0	6.40	20.0	102.00	16.0	31.00
18.0	7.30	21.0	97.00	18.0	40.00
20.0	8.30	22.0	90.00	20.0	60.00
22.0	9.30	23.0	85.00	22.0	75.00
24.0	4.50	24.0	70.00		↓
26.0	4.00	25.0	55.00		
28.0	4.20	27.0	5.00		full scale
30.0	4.50		↓		immediately
32.0	4.00		0		
34.0	4.00		immediatly		
36.0	4.00				
38.0	4.20				
40.0	4.00				
50.0	4.00				
60.0	4.00				

Table 5.11 Conductivity measurement of inorganic compound.

KF		$CoCl_2.6H_2O$		KNO_3	
26.8°C thickness 1.670 mm.		25.2°C thickness 2.820 mm.		25.5°C thickness 1.720 mm.	
voltage (v)	microampere (μA)	voltage (v)	microampere (μA)	voltage (v)	microampere (μA)
0.0	0.00	0.0	0.00	0.0	0.00
0.5	1.00	1.0	0.00	10.0	0.20
1.0	2.50	2.0	10.00	20.0	0.40
1.5	12.50	3.0	25.00	30.0	0.70
2.0	23.00	4.0	44.00	40.0	1.00
2.5	50.00	5.0	60.00	50.0	1.20
3.0	85.00	6.0	80.00	60.0	1.50
3.5	138.00	7.0	100.00	70.0	1.85
4.0	195.00	8.0	124.00	80.0	2.15
	↓	9.0	144.00	90.0	2.50
		10.0	164.00	100.0	2.90
	full scale	11.0	198.00	110.0	3.20
	immediately	12.0	226.00	115.0	3.70
		13.0	232.00	120.0	3.20
		14.0	256.00	125.0	4.20
		15.0	274.00	130.0	3.20
		16.0	296.00	135.0	4.50
				140.0	3.30
				145.0	4.10
				150.0	3.10
				155.0	4.00
				160.0	3.20
				165.0	4.00
				170.0	3.30

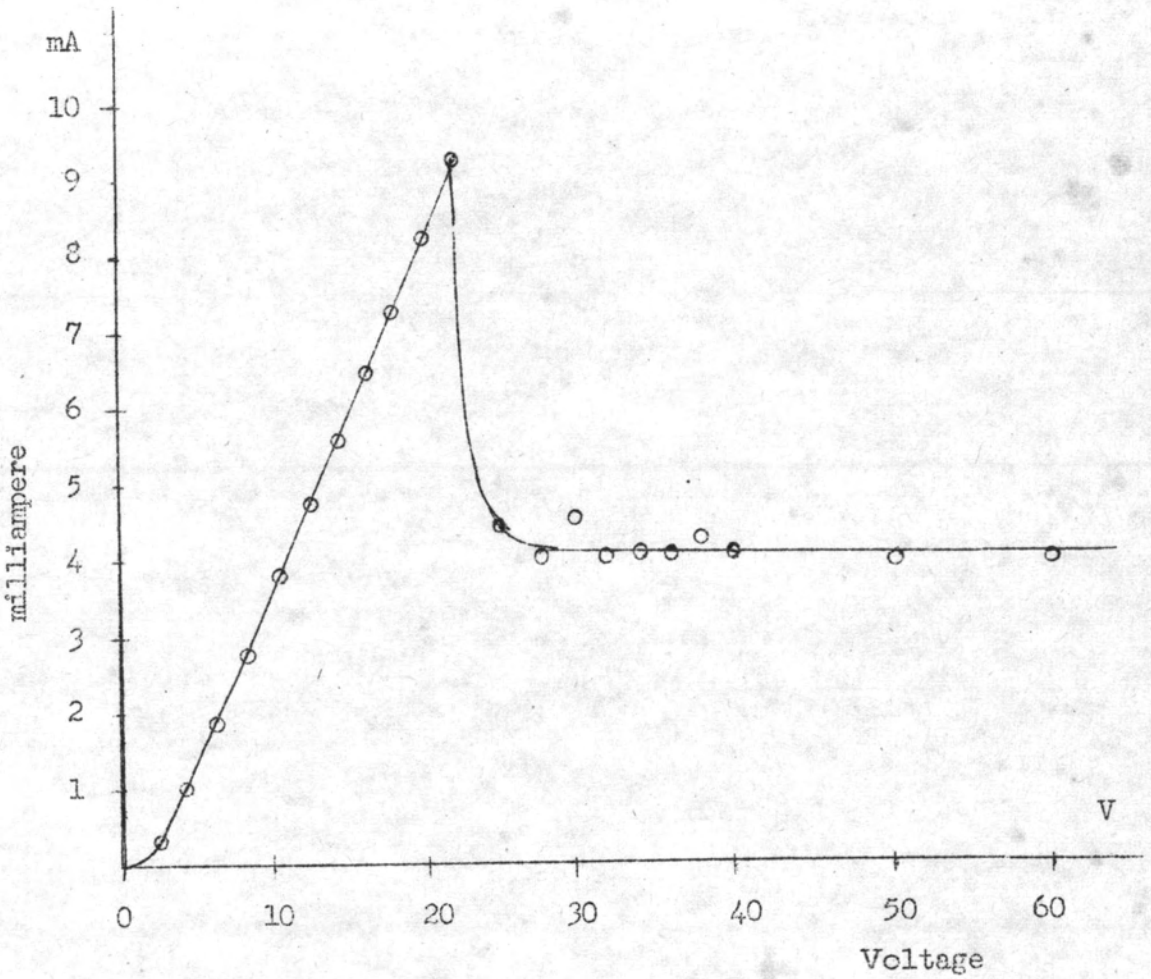


Fig. 5.11 Conductivity measurement of KCN

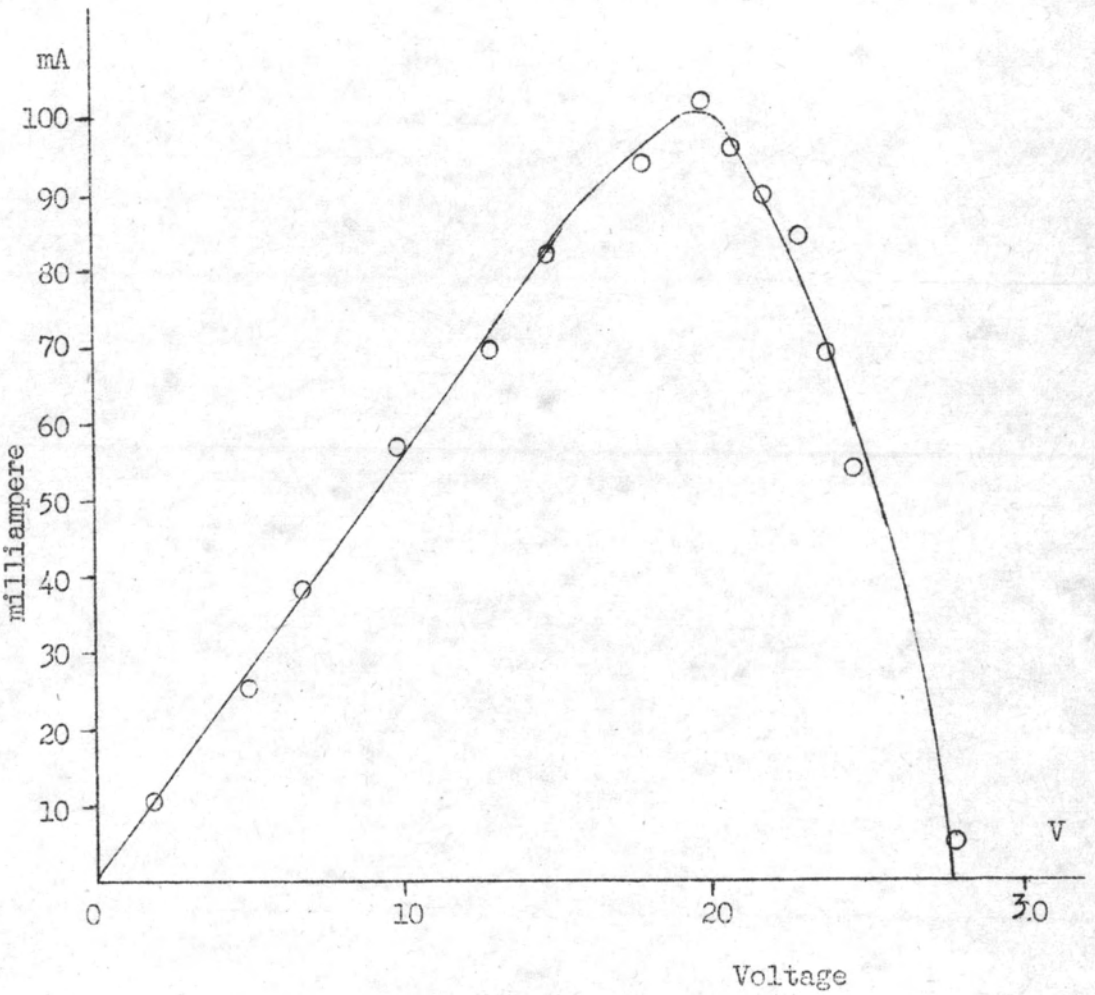


Fig 5.12 Conductivity measurement Of KCNO

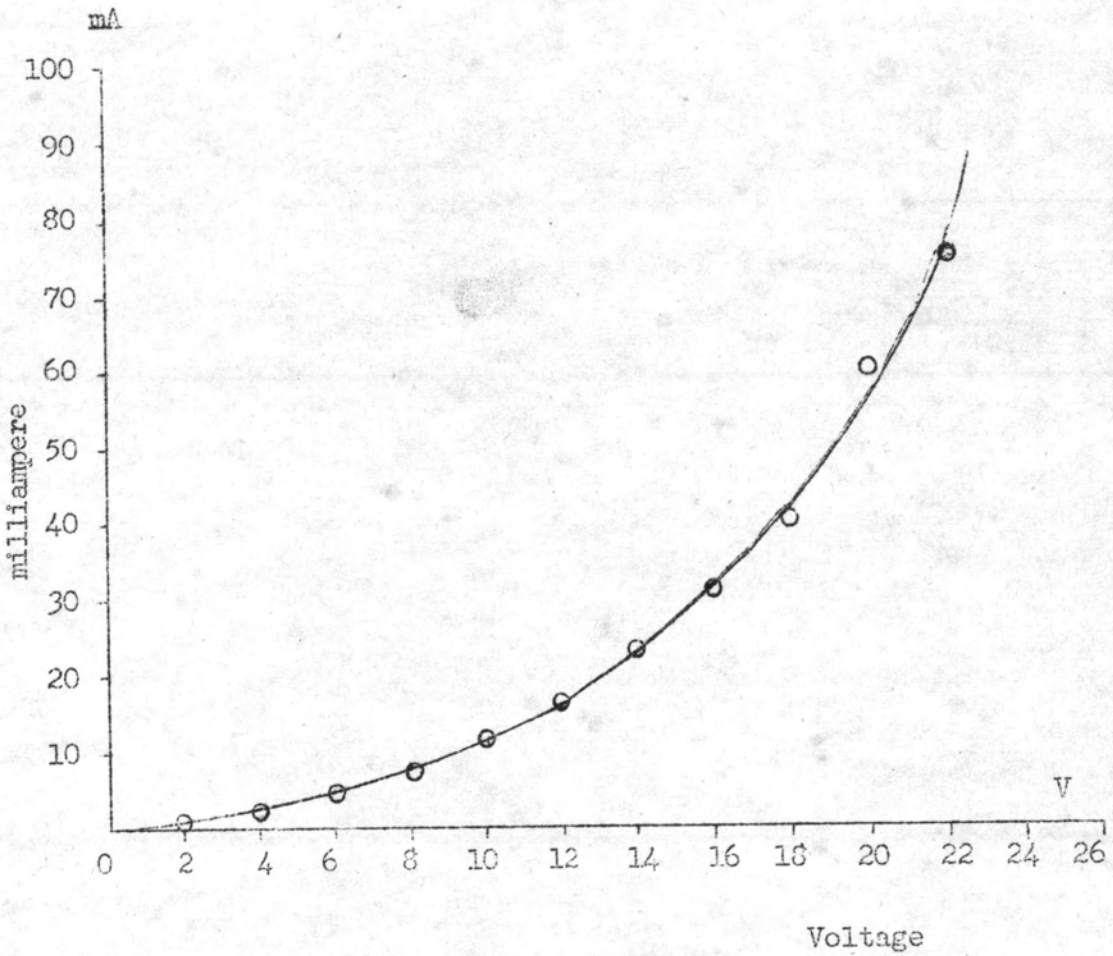


Fig 5.13 Conductivity measurement of $Ni(NO_3)_2.6H_2O$

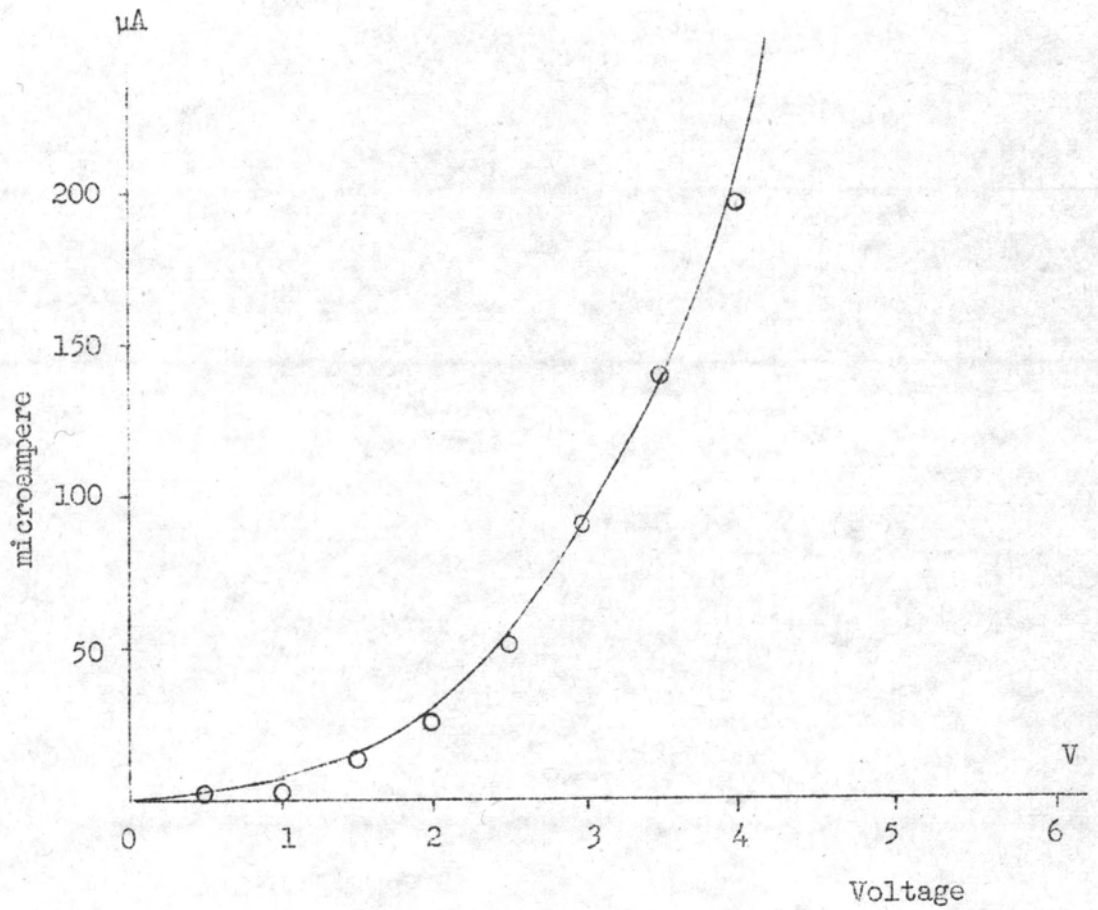


Fig 5.14 Conductivity measurement of KF

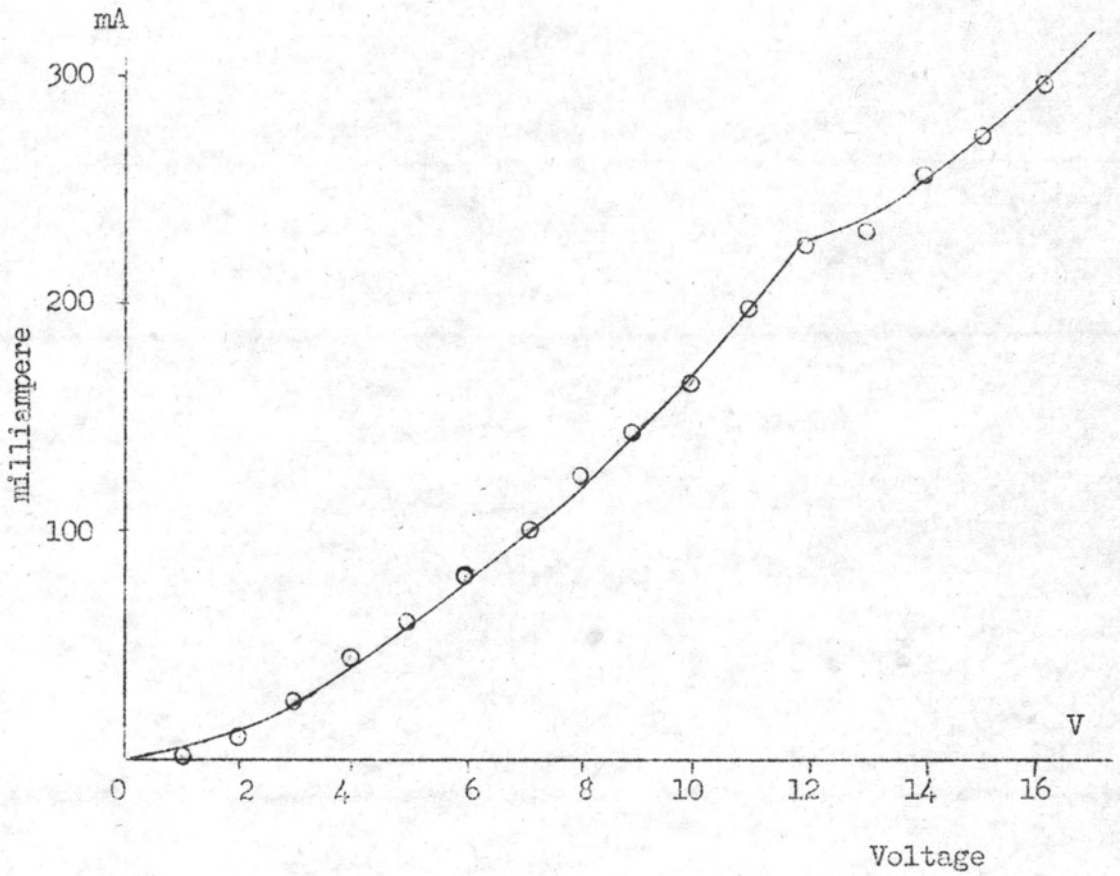


Fig 5.15 Conductivity measurement of $CoCl_2.6H_2O$

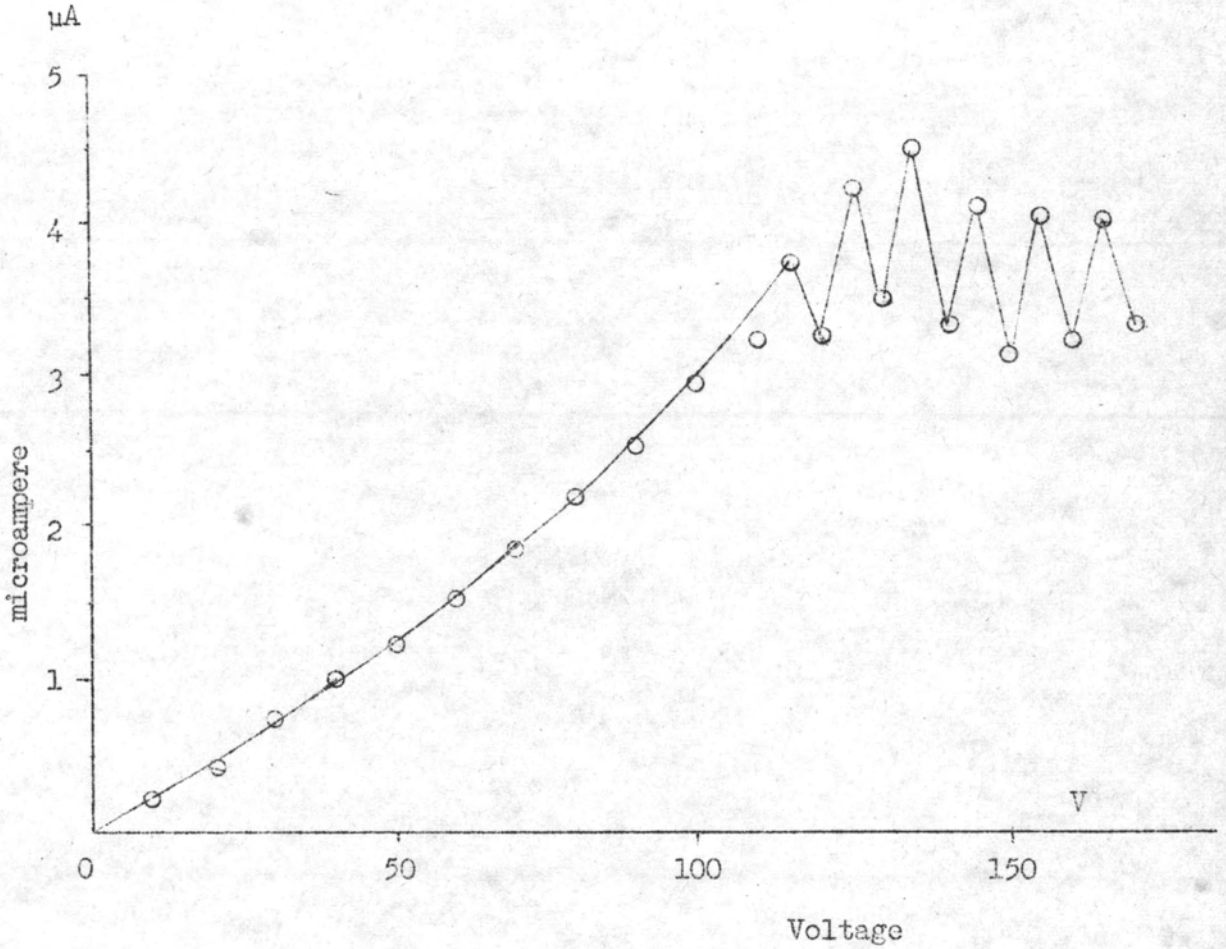


Fig 5.16 Conductivity measurement of KNO_3

The current of some compounds increased continuously with applied voltage but in some range of voltage only, the deviation often appeared at the higher one. There was an optimum voltage for each system of this type. There were several types of current distortion and results was explained graphically in detail. For some compounds, the relationship between current and voltage increased continuously over 400 volt which was the highest voltage to be supplied.

5.6.2 The conductivity measurement of solid-solid reactions.

Reactions between solid and solid was capable to take place by the diffusion mechanism. In such the diffusion process, some species migrated through crystal lattice. The observation at any applied voltage could be followed by measuring current at given time. The value of current per unit of voltage was related to the conductivity of system. The voltage was kept consistently while the solid-solid interaction was being in progress, which caused the change in current and to be able to measure. The relationship between current and time at constant voltage was tabulated and represented all the study of solid-solid reaction in the form of graphic group.

Table 5.12 Conductivity measurement of solid-solid reaction.

$NiSO_4.6H_2O$ + KCN		KNO_3 + $CoCl_2.6H_2O$		$NiSO_4.6H_2O$ + $(NH_4)_2CO_3$	
$NiSO_4.6H_2O$	2.080 mm	KNO_3	1.740 mm	$NiSO_4.6H_2O$	2.090 mm
KCN	2.042 mm	$CoCl_2.6H_2O$	2.770 mm	$(NH_4)_2CO_3$	2.710 mm
50V.	25.6°C	3V.	26.2°C	30V.	26.8°C
time (minute)	miercampere (μA)	time (minute)	microampere (μA)	time (minute)	microampere (μA)
0.0	3.60	0.0	3.90	0.0	1.80
0.5	2.00	2.0	1.90	2.0	2.50
1.0	1.40	4.0	1.42	4.0	3.00
1.5	1.10	6.0	1.20	6.0	3.90
2.0	1.00	8.0	1.00	8.0	5.10
2.5	0.80	10.0	0.90	10.0	6.20
3.0	0.70	12.0	0.80	12.0	8.00
3.5	0.70	14.0	0.70	14.0	9.60
4.0	0.60	16.0	0.60	16.0	10.40
4.5	0.60	18.0	0.58	18.0	9.50
5.0	0.60	20.0	0.50	20.0	12.20
5.5	0.60	22.0	0.53	22.0	12.60
6.0	0.65	23.0	0.50	24.0	12.20
7.0	0.60	25.0	0.50	26.0	12.00
8.0	0.60	30.0	0.50	28.0	11.40
9.0	0.55	35.0	0.50	30.0	10.50
10.0	0.60	40.0	0.50	32.0	9.30
11.0	0.55	50.0	0.50	34.0	8.40
12.0	0.60	60.0	0.50	36.0	7.50
				38.0	7.00
				40.0	6.50
				45.0	5.40
				50.0	4.60
				55.0	4.10
				60.0	3.80

Table 5.12 Conductivity measurement of solid-solid reaction.

$Ni(NO_3)_2.6H_2O + (NH_4)_2C_2O_4$		$NiCl_2.6H_2O + (NH_4)_2C_2O_4$		$KCNO + (NH_4)_2CrO_4$		
$Ni(NO_3)_2.6H_2O$ 1.860 mm		$NiCl_2.6H_2O$ 2.440 mm		KCNO 1.780 mm		
$(NH_4)_2C_2O_4$ 2.320 mm		$(NH_4)_2C_2O_4$ 2.300 mm		$(NH_4)_2CrO_4$ 1.960 mm		
30V. 25.4°C		15V. 26.4°C		80V. 26.5°C		
time (minute)	microampere (μA)	time (minute)	microampere (μA)	time (minute)	microampere	
					μA_1	μA_2
0.0	1.55	0.0	7.50	0.0	0.2	0.42
1.0	1.10	1.0	5.80	1.0	0.33	0.35
2.0	0.90	2.0	5.00	2.0	0.39	0.29
3.0	0.80	3.0	4.45	3.0	0.43	0.26
4.0	0.72	4.0	4.10	4.0	0.46	0.23
5.0	0.70	5.0	3.90	5.0	0.47	0.22
6.0	0.68	6.0	3.80	6.0	0.48	0.22
7.0	0.70	7.0	3.50	7.0	0.49	0.20
8.0	0.78	8.0	3.40	8.0	0.48	0.21
9.0	0.90	9.0	3.30	10.0	0.49	0.20
10.0	1.10	10.0	3.20	12.0	0.48	0.20
11.0	1.60	11.0	3.10	14.0	0.49	0.21
	↓	12.0	3.00	16.0	0.48	0.20
		13.0	2.95	18.0	0.48	0.20
	full scale	14.0	2.90	20.0	0.48	0.21
	immediately			25.0	0.48	0.20
				30.0	0.48	0.20

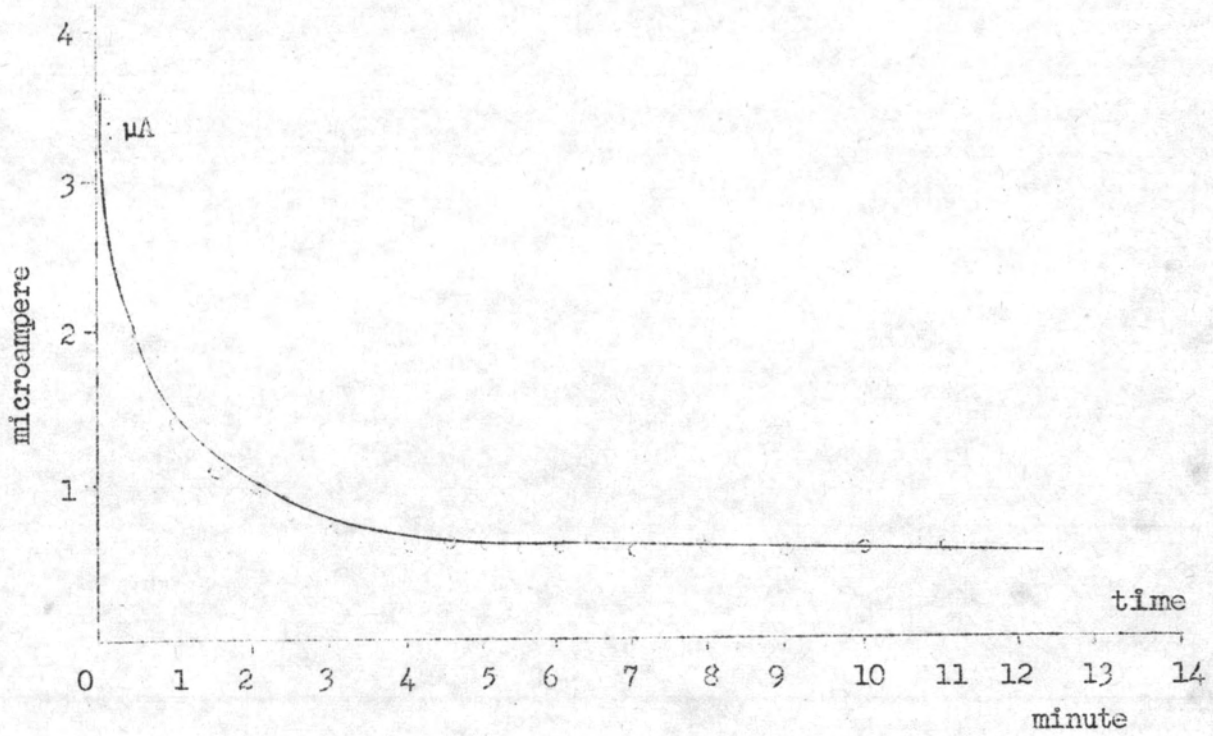


Fig 5.17 Conductivity of solid-solid reaction $NiSO_4.6H_2O$ + KCN

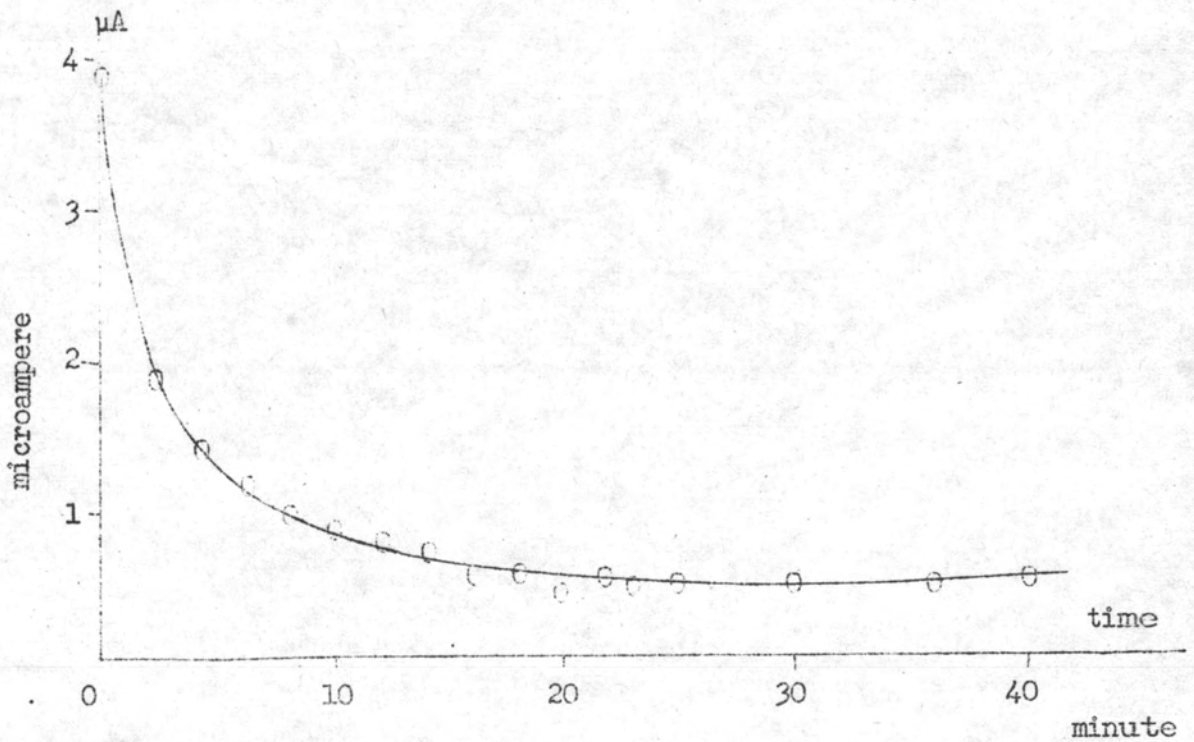


Fig 5.18 Conductivity of solid-solid reaction KNO_3 + $CoCl_2.6H_2O$

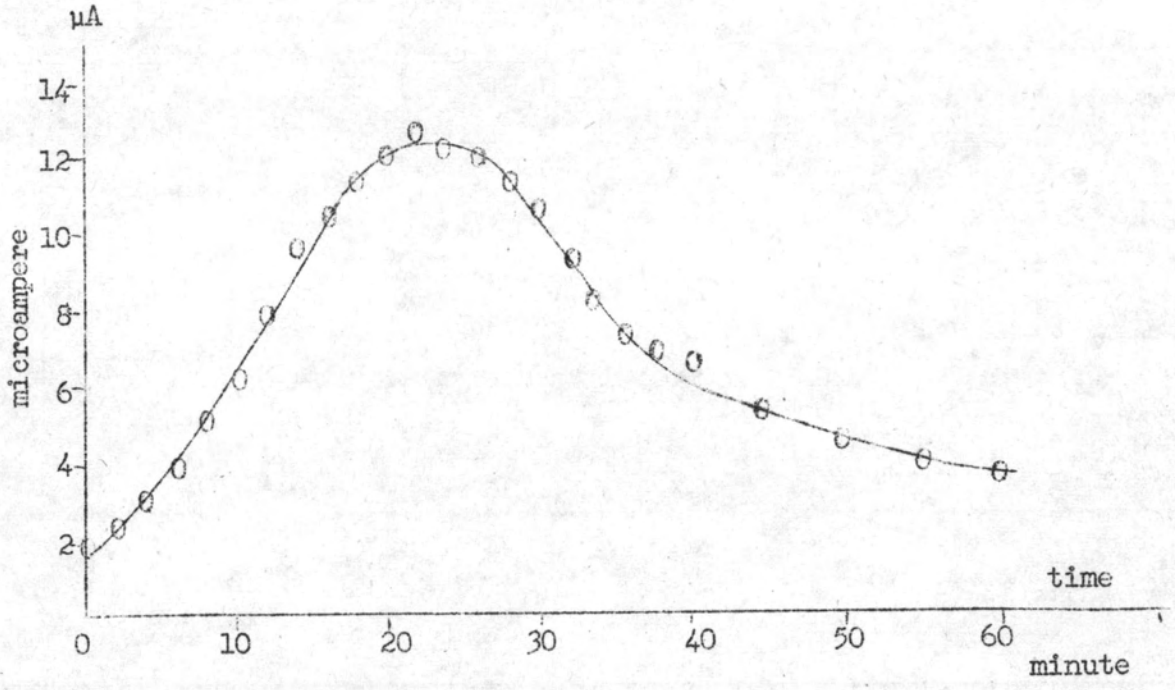


Fig 5.19 Conductivity of solid-solid reaction $NiSO_4.6H_2O + (NH_4)_2CO_3$

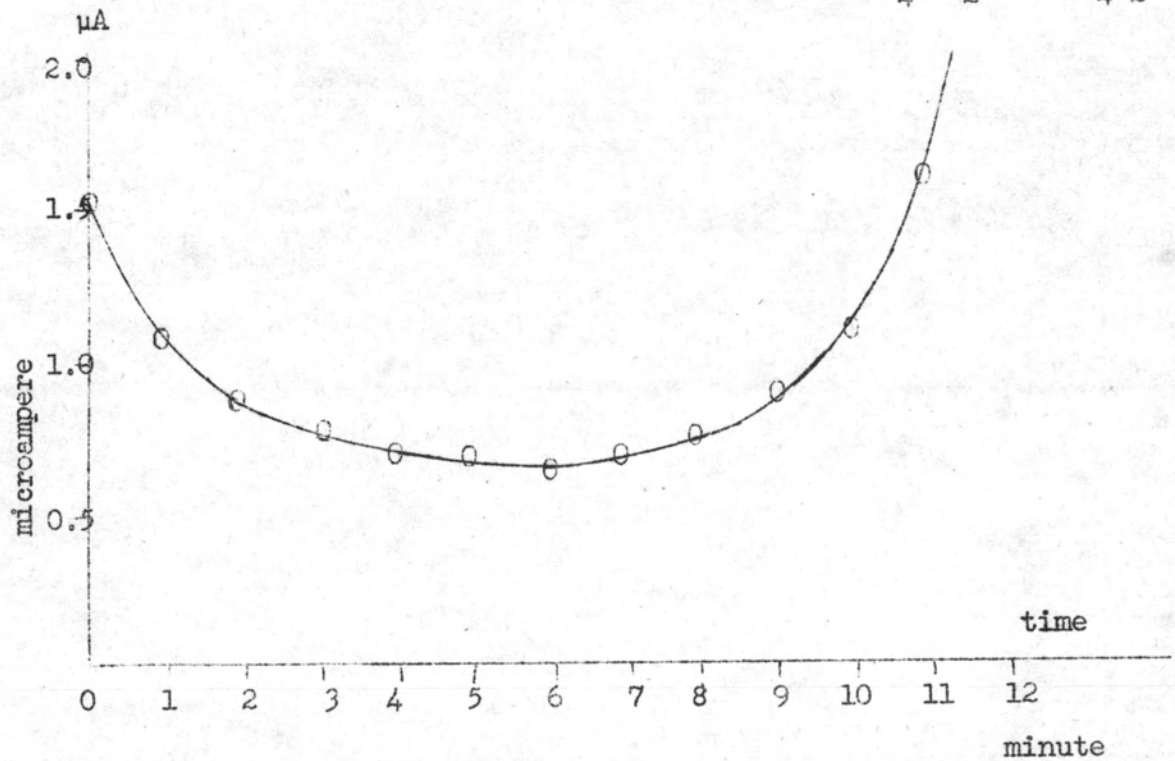


Fig 5.20 Conductivity of solid-solid reaction $Ni(NO_3)_2.6H_2O+(NH_4)_2C_2O_4$

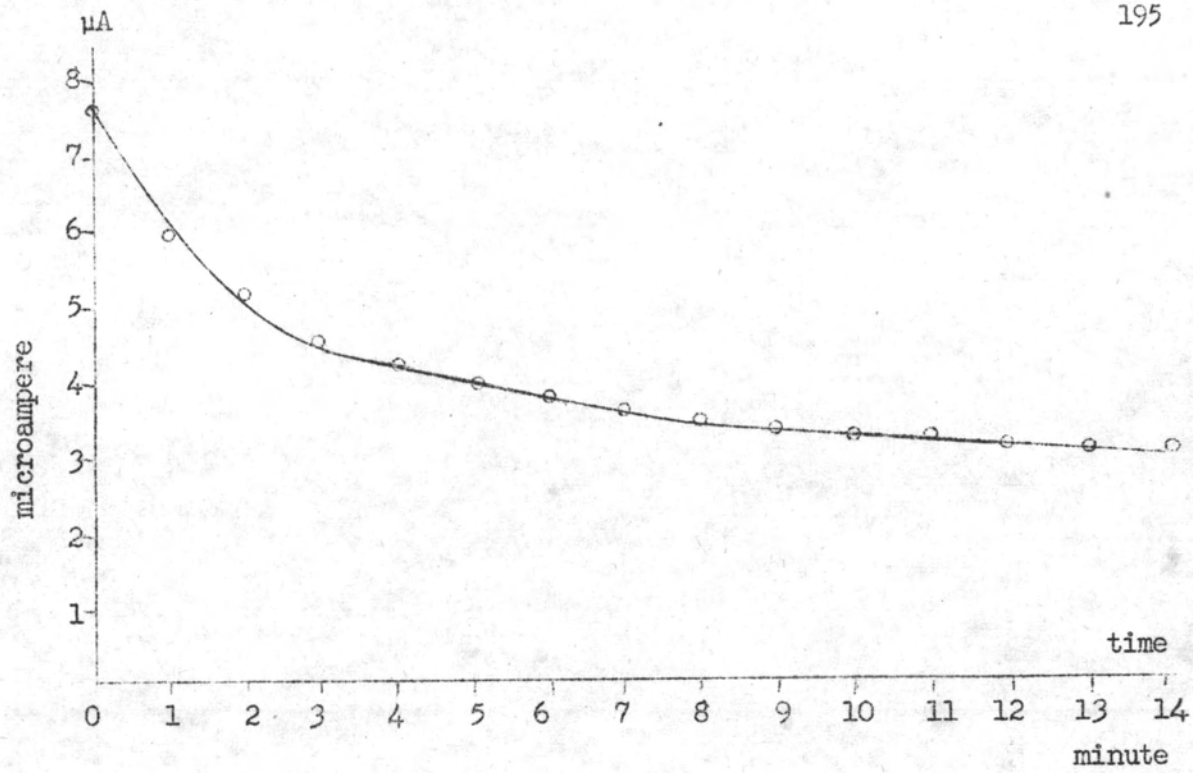


Fig 5.21 Conductivity of solid-solid reaction $NiCl_2.6H_2O + (NH_4)_2C_2O_4$

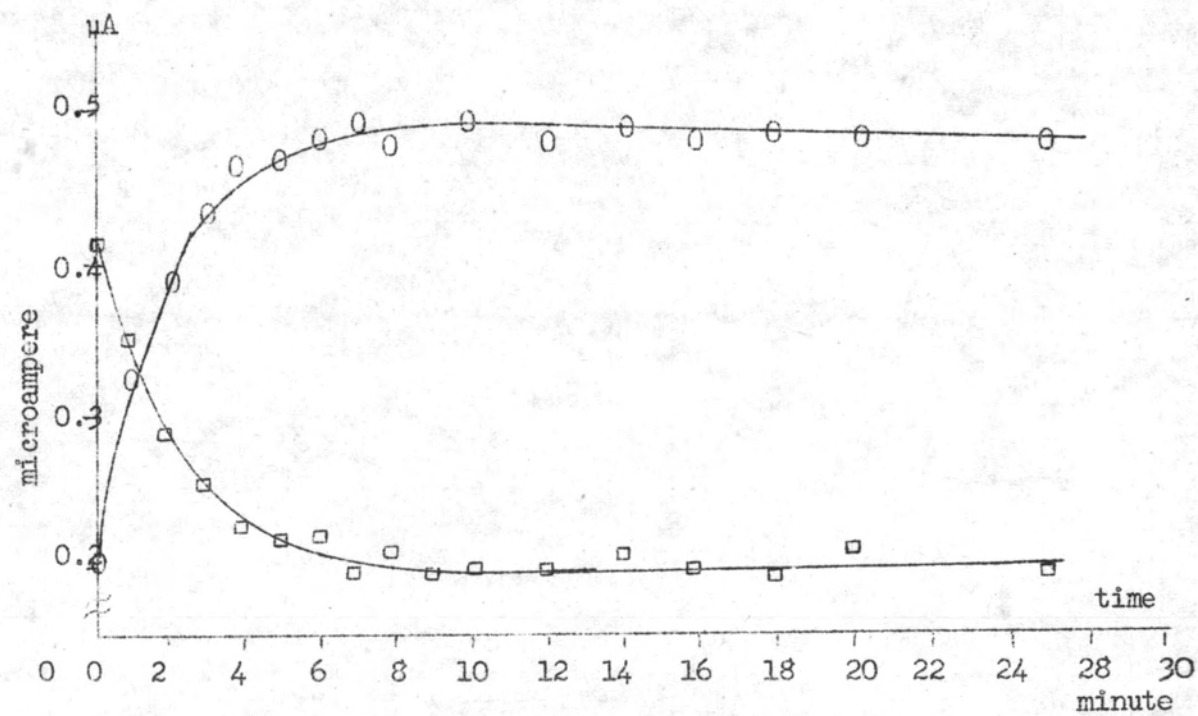


Fig 5.22 Conductivity of solid-solid reaction $KCNO + (NH_4)_2CrO_4$

5.7 Concluding remarks and the suggestion for future work

A knowledge of the diffusion in and through crystal lattice is a prerequisite to understand the possibility of both physical and chemical change while the study focused the attention on the subject of solid-solid phenomena. Some special and suitable implements should have been constructed with facile technique in order to provide easily the reliable evidence. The study of solid-solid chemistry seems to be a very wide field of science knowledge. Any suggestion work showing below can be enlarged for forming individual research programme.

a. pursuit the time expenditure of solid-solid interaction at variety of temperature.

b. the kinetic study of solid-solid reaction

c. the structural study of reaction product

d. the study of solid-solid chemistry which may affect some analytical techniques

e. the application of solid-solid chemistry to prolong the deterioration of solid material and etc.

The advantage of solid state reaction must be applied to solid-state science such as solid-state physics, metallurgist, engineering and etc. It seems to be one of interdisciplinarity for solid-state study.