① $A \vee (B \vee C) \vdash A \vee (B \vee (C \vee D))$

$\vdash_{\text{дано}} A \vee (B \vee C) \vdash_{\Pi_1} D \vee (A \vee (B \vee C)) \vdash_{\Pi A} (D \vee A) \vee (B \vee C) \vdash_{\Pi K}$

$\vdash_{\Pi K} (B \vee C) \vee (D \vee A) \vdash_{\Pi A} ((B \vee C) \vee D) \vee A \vdash_{\Pi A} (B \vee (C \vee D)) \vee A \vdash_{\Pi K} A \vee (B \vee (C \vee D))$

② $A \vee (B \vee (A \vee C)) \vdash B \vee (A \vee C)$

$\vdash_{\text{дано}} A \vee (B \vee (A \vee C)) \vdash_{\Pi A}$ ~~$B \vee (A \vee (A \vee C))$~~ $\vdash_{\Pi K} (B \vee (A \vee C)) \vee A \vdash_{\Pi A}$

~~$\vdash_{\Pi A} (B \vee A) \vee (A \vee C) \vdash_{\Pi_1} C \vee ((B \vee (A \vee C)) \vee A) \vdash_{\Pi K} ((B \vee (A \vee C)) \vee A) \vee C \vdash_{\Pi A}$~~

$\vdash_{\Pi A} (B \vee (A \vee C)) \vee (A \vee C) \vdash_{\Pi K} (A \vee C) \vee (B \vee (A \vee C)) \vdash_{\Pi_1} B \vee ((A \vee C) \vee$

$\vee (B \vee (A \vee C))) \vdash_{\Pi A} (B \vee (A \vee C)) \vee (B \vee (A \vee C)) \vdash_{\Pi_2} B \vee (A \vee C)$ (#)

③ $A \vee (B \vee C) \vdash A \vee (C \vee B)$

$\vdash_{\text{дано}} A \vee (B \vee C) \vdash_{\Pi K} (B \vee C) \vee A \vdash_{\Pi A} B \vee (C \vee A) \vdash_{\Pi K} (C \vee A) \vee B \vdash_{\Pi A}$

~~$\vdash_{\Pi A} (C \vee B) \vee A$~~ $\vdash_{\Pi K} A \vee (C \vee B)$

④ $\vdash (A \vee A) \to A \qquad \vdash \neg(A \vee A) \vee A$

$\vdash_{Ax}$ ~~$\neg A \vee A$~~ $\neg(A \vee A) \vee (A \vee A) \vdash_{\Pi A} (\neg(A \vee A) \vee A) \vee A \vdash_{\Pi K}$

$\vdash_{\Pi K} A \vee (\neg(A \vee A) \vee A) \vdash_{\Pi_1} A \vee (A \vee (\neg(A \vee A) \vee A)) \vdash_{\Pi A}$

$\vdash_{\Pi A} (A \vee A) \vee (\neg(A \vee A) \vee A) \vdash_{\Pi_2} \neg(A \vee A) \vee A$

⑤ $(A \to B) \to C \vdash A \vee C \qquad \neg(\neg A \vee B) \vee C \vdash A \vee C$

$\vdash_{\text{дано}} \neg(\neg A \vee B) \vee C \vdash$

$\vdash_{Ax} \neg A \vee A \vdash_{\Pi K} A \vee \neg A \vdash_{\Pi_4} B \vee (A \vee \neg A) \vdash_{\Pi K} (A \vee \neg A) \vee B \vdash_{\Pi A}$

$\vdash_{\Pi A} A \vee (\neg A \vee B) \vdash_{\Pi_4} A \vee C$