FINDING CCA GROUPS AND GRAPHS ALGORITHMICALLY

BRANDON FULLER
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BRANDON FULLER

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Dr. Joy Morris Supervisor	Professor	Ph.D.
Dr. Dave Witte Morris Committee Member	Professor	Ph.D.
Dr. Shelly Wismath Committee Member	Professor	Ph.D.
Dr. Hadi Kharaghani Chair, Thesis Examination Committee	Professor	Ph.D.

Abstract

Given a group G, any subset C of $G\backslash\{e\}$ induces a Cayley graph, $Cay(G,C)$. The set C also induces a natural edge-colouring of this graph. All affine automorphisms of the Cayley graph preserve this edge-colouring. A Cayley graph $Cay(G,C)$ has the Cayley Colour Automorphism Property (is CCA), if all its colour-preserving automorphisms are affine. A group G is CCA if every connected Cayley graph on G is CCA. The goal of this thesis is to classify all groups of small order to determine if they are CCA. In order to do this, we have developed two main algorithms that are the new contributions of this thesis. One algorithm finds all minimal generating sets for any group. The other algorithm uses this to test whether or not a group is CCA. These algorithms can also be used to determine whether or not a given Cayley graph is CCA.

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Contents

Chapter 1

Introduction

The Cayley Colour Automorphism (CCA) property is a certain property that some finite groups have, and others do not (see Definition 1.7 for the precise definition). The study of this property has only come up recently in history. In early 2012, M. Conder, T. Pizanski and A. Žitnik [3] proposed a question to J. Morris about the permutations on circulant graphs that preserved a certain edge colouring. In the middle of 2012 J. Morris [15] answered by showing that for any connected circulant graph on $\mathbb{Z}_n$, all of these colour-preserving automorphisms that fix the identity are automorphisms of $\mathbb{Z}_n$. In 2014, A. Hujdurović, K. Kutnar, D. W. Morris, and J. Morris [11] extended the original question by looking at more general graphs (Cayley graphs) and using the natural edge colouring that we will describe. Recently in 2016, E. Dobson, A. Hujdurović, K. Kutnar, and J. Morris [5] improved some of the results that had been proven when the order of G is odd and square free. Also in early 2017, L. Morgan, J. Morris and G. Verret [14], [13] gave some new results for finite simple groups and Sylow cyclic groups which generalized the results of [5].

The problem of determining colour-preserving and colour-permuting automorphisms for Cayley digraphs has already been studied and is well understood. In [18] the authors showed that for every connected Cayley digraph, every colour-preserving automorphism of it is a left-translation by some element of the group. In [7] the authors showed that every colour-permuting automorphism is affine. As we shall see, the situation is much more complex when we consider graphs rather than digraphs, so that a generator and its inverse are forced to have the same colour.

In Chapter 2 we review the main results of the aforementioned papers and discuss how their results can be applied to determine whether a group is CCA or not. Then in Chapter 3 we introduce a new algorithm which takes in a group as input and outputs whether or not that group is CCA or non-CCA. A program was written using this algorithm using both GAP [8] and Sage [17] and ran on all groups up to order 200 (except orders 128 and 192). The results of this program are provided in Appendix B. In Chapter 4 we make some observations about these results. Also in Chapter 4 we discuss another application for one piece of the general algorithm.

1.1 Notation

Notation 1.1. The following will hold for the remainder of the thesis:

- G and G_i will represent groups of finite order.
- the identity of the group G, will be denoted e or e_G.
- C will represent a subset of $G\backslash\{e\}$.
- $Cay(G,C)$ will be the notation used for the Cayley graph (See Definition 1.5) of the group G with connection set C. For the special case $C = G\backslash\{e\}$ we denote $K_G = Cay(G, G\backslash\{e\})$ (the complete graph viewed as a Cayley graph).
- $\langle C\rangle$ (called the group generated by C) is the smallest subgroup of G that contains every element of C.
- $Aut(G)$ denotes the group of automorphisms of G.
- $X = (V(X), E(X))$ will represent a graph of finite order, consisting of a set $V = V(X)$ of vertices and a set $E = E(X) \subseteq V \times V$ of edges.
- $\mathcal{L}(X)$ denotes the line graph of X. That is, $\mathcal{L}(X)$ is the graph where the vertices correspond to the edges of X and there is an edge between two vertices in $\mathcal{L}(X)$ if the corresponding edges share a vertex in X.

- $N(v)$ is the set of neighbours of the vertex v in a graph.
- If G acts on a graph X and $S \subseteq V(X)$ then G^S is the restriction of the action of G to S.
- The symbol $\sim$ will be used to show that two vertices are adjacent in a graph. That is, if v and u are vertices of a graph, $v \sim u$ means that there is an edge between v and u in that graph. Likewise, $\nsim$ means two vertices do not have an edge between them.

In Section 2.5 we use the following notation.

Notation 1.2. For a fixed Cayley graph $Cay(G,C)$:

- $\mathcal{A}^0$ is the group of all colour-preserving automorphisms (see Definition 1.6) of the Cayley graph $Cay(G,C)$.
- $\widehat{G}$ is the subgroup of $\mathcal{A}^0$ consisting of all left translations by elements of G.
- H_e is the stabilizer of e in $Cay(G,C)$, for any $H \subseteq \mathcal{A}^0$ (see Definition 1.17).

1.2 The Basics

In this section we will introduce the basic definitions and facts that will lay the foundation needed for the rest of the thesis. We note that we do not include every definition. Any definition we do not include can be found in one of [2, 4, 9, 10].

Definition 1.3 ([2, p. 1])**.** A graph X is connected if there is a path from every vertex of $V(X)$ to every other vertex of $V(X)$.

Definition 1.4 ([2, p. 6])**.** An **automorphism** of a graph is a permutation of the vertex set that preserves edges and non-edges. More explicitly, we have that φ is an automorphism of X if φ is a bijection on $V(X)$ and $v \sim u \Leftrightarrow \varphi(v) \sim \varphi(u)$ for all vertices v and u in X.

Definition 1.5 ([9, p. 34])**.** The **Cayley graph** of G with respect to C (a subset of $G \backslash \{e\}$) is the graph $Cay(G,C)$ whose vertices are the elements of G, and with an edge from g to gc for each $g \in G$, $c \in C$.

Since we are talking about a graph instead of a digraph, we ignore the technicalities of $c, c^{-1} \in C$ since having them both would result in the same graph (as we do not allow more than one edge between two vertices). We say a colouring of a set is a function that maps each element to a colour. With the definition of a Cayley graph, we can see that there is a natural colouring of the edges of $Cay(G,C)$. We colour the edge from g to gc (and gc to g) with a colour associated to $\{c, c^{-1}\}$. This in turn lets us consider automorphisms of $Cay(G,C)$ that preserve the colours that we associate with each edge.

Definition 1.6 ([11, p. 190])**.** An automorphism of $Cay(G,C)$ is called a **colour-preserving automorphism** if it preserves the natural edge colouring. More explicitly φ is a colour-preserving automorphism if and only if φ is an automorphism and we have $\varphi(gc)$ is in $\{\varphi(g)c, \varphi(g)c^{-1}\}$ for each $g \in G$, $c \in C$.

Two easy-to-understand automorphisms are immediate from this definition. For any $g' \in G$ the left translation $g \mapsto g'g$ is a colour-preserving automorphism of $Cay(G,C)$ since $g'(gc) = (g'g)c$ for any $g \in G, c \in C$. Also if α is an automorphism of G with $\alpha(c) \in \{c, c^{-1}\}$ for all $c \in C$, then α is a colour-preserving automorphism. In several cases, all colour-preserving automorphisms of $Cay(G,C)$ are obtained by a composition of these two types of automorphisms, which leads us to our next definition.

Definition 1.7 ([11, Definition. 1.2])**.**

- A function $\varphi : G \to G$ is **affine** if it is a composition of an automorphism of G with left translation by an element of G. More specifically $\varphi(g) = \alpha(g'g)$ for some $\alpha \in Aut(G)$ and $g' \in G$.

- A Cayley graph $Cay(G,C)$ has the **Cayley Colour Automorphism property** if all of its colour-preserving automorphisms are affine functions on G. In this case, we say $Cay(G,C)$ is CCA.

- A group G has the **Cayley Colour Automorphism property** if every connected Cayley graph on G is CCA. In this case, we say G is CCA.

For the definition of a group to be CCA we need to restrict our consideration to connected Cayley graphs. The reason we need the graph to be connected is that if there were two nontrivial components of the graph, we could apply a left translation by an element of $\langle C \rangle$ to some component that does not include the identity and leave the rest fixed. It can be seen that this would be a colour-preserving automorphism that is not affine. Similarly, if every component is trivial then the graph is $\overline{K_n}$ and its automorphism group is S_n, which clearly includes elements that are not affine whenever $n \geq 4$. Thus, if we allowed disconnected Cayley graphs, the only CCA groups would be C_2 and C_3.

Another useful way to see when a Cayley graph is CCA is to see if $\widehat{G}$ is a normal subgroup of its colour-preserving automorphisms. This is a consequence of the following remark.

Remark 1.8. It is known that a permutation of G is affine if and only if it normalizes $\widehat{G}$ (see, for example [16, Lem. 2]).

We consider another definition very similar to colour-preserving automorphism. This new definition allows for the permutation of the colours as well as preserving them.

Definition 1.9 ([11, Definition. 1.4])**.**

- An automorphism α is a **colour-permuting automorphism** of a Cayley graph $Cay(G,C)$ if it respects the colour classes. That is there exists π a permutation of C such that $\alpha(gc) \in \{\alpha(g)\pi(c), \alpha(g)\pi(c)^{-1}\}$ for all $g \in G$ and $c \in C$ (with $\pi(c^{-1}) = \pi(c)^{-1}$).

- We say G is **strongly CCA** if every colour-permuting automorphism of every connected Cayley graph on G is affine.

Clearly, if G is strongly CCA then G is CCA (we can take π to be the identity map), but the converse is not true. To study every connected Cayley graph of a group G it is useful to know exactly what conditions C would need, to have it generate a connected Cayley graph. For that we introduce a well known fact about Cayley graphs (see, for example [9, Lem. 3.7.4, p. 49]).

Lemma 1.10 ([9, Lem. 3.7.4, p. 49]). *$Cay(G,C)$ is connected if and only if C generates G.*

Proof. ($\Rightarrow$) Let $g \in G$ be arbitrary. Since $Cay(G,C)$ is connected there is some path between the identity vertex and g. Let $c_1,...,c_n \in C$ be the elements corresponding to the edges (in order) taken in the path from e to g. Thus by the definition of Cayley graphs, $g = c_1...c_n$. Thus $g \in \langle C\rangle$ and since g was arbitrary $G \subseteq \langle C\rangle$. Also since $\langle C\rangle \subseteq G$ we have $\langle C\rangle = G$.

($\Leftarrow$) Let $g_1, g_2 \in G$ be arbitrary and suppose C generates G. Then $\exists c_1,...,c_n \in C$ such that $c_1...c_n = g_1^{-1}g_2$. By the definition of Cayley graphs we have an edge from g_1 to g_1c_1. Similarly we have an edge from $g_1c_1...c_i$ to $g_1c_1...c_{i+1}$ for $i \in \{1,...,n-1\}$, and thus a path from g_1 to $g_1c_1...c_n = g_1g_1^{-1}g_2 = g_2$ in $Cay(G,C)$. □

Since Cayley graphs have a very natural edge colouring, it seems intuitive to study what kind of automorphisms of these graphs can preserve these colours. Our main goal of this thesis is to classify what groups and Cayley graphs are and are not CCA to help understand the automorphisms of Cayley graphs.

Later, in Corollary 2.4, we will see that the following two families of groups are examples of non-CCA groups.

Definition 1.11. [11, Definition. 2.6] Let A be an abelian group of even order. Choose an involution y of A. The corresponding **generalized dicyclic group** is

$$Dic(y,A) = \langle x, A \mid x^2 = y, x^{-1}ax = a^{-1} \forall a \in A\rangle.$$

Definition 1.12. [11, Definition. 2.7] For $n \geq 1$, we define

$$SemiD_{16n} = \langle a, x \mid a^{8n} = x^2 = e, xa = a^{4n-1}x\rangle$$

as the **semidihedral group**.

The following definition will be used in Section 2.4 where we will classify when these groups are (strongly) CCA.

Definition 1.13. [11, Definition. 5.1] The **generalized dihedral group** over an abelian group A is the group

$$Dih(A) = \langle \sigma, A \mid \sigma^2 = e, \sigma a \sigma = a^{-1} \forall a \in A \rangle$$

which is called the **dihedral group** if A is cyclic.

In Section 2.5 we will use Definitions 1.14, 1.15 and Lemma 1.16 for some of the proofs. Lemma 1.16 is a very well known fact taught in elementary group theory (see, for example [10, p. 32]).

Definition 1.14 ([10, p. 26])**.** A subgroup H of G is called a **normal subgroup**, denoted $H \triangleleft G$, if $\forall g \in G$, $gH = Hg$.

Definition 1.15 ([10, p. 31])**.** A subgroup H of G is called a **characteristic subgroup**, denoted $H\mathrm{charG}$, if $\forall \varphi \in Aut(G)$, $\varphi(H) = H$.

Lemma 1.16 ([10, p. 32])**.** *If* $K\mathrm{charH} \triangleleft \mathrm{G}$ *then* $K \triangleleft G$*.*

Definition 1.17 ([4, p. 8], [9, p. 20])**.** If G acts on a set Ω and v is an element of Ω then the **stabilizer** of v with respect to G is $G_v = \{g \in G : g(v) = v\}$.

The following two definitions will be used in Section 2.1 to help show that the non-abelian group of order 21 is not CCA.

Definition 1.18 ([12, Definition 1.1])**.** Let X be a graph and G a permutation group acting on the edges of X. We say that X is a G**-edge-regular graph** if for each pair of edges e_1 and e_2 of X, there exists a unique element of G that maps e_1 to e_2.

Definition 1.19 ([14, Definition 4.5])**.** Let B be a permutation group and G a regular subgroup of B. Let $\mathcal{A}^0$ be the colour-preserving automorphism group for the Cayley graph K_G. We say that (G,B) is a **complete colour pair** if B is a subgroup of $\mathcal{A}^0$ and G is one of the following:

- G is abelian but not an elementary abelian 2-group, and $\mathcal{A}^0 = Dih(G)$.
- $G \cong Dic(A,y)$ but not of the form $Q_8 \times C_2^n$ and $\mathcal{A}^0 = \widehat{G} \rtimes \langle \sigma \rangle$, where σ is the permutation that fixes A pointwise and maps every element of the coset Ax to its inverse.
- $G \cong Q_8 \times C_2^n$ and $\mathcal{A}^0 = \langle \widehat{G}, \sigma_i, \sigma_j, \sigma_k \rangle$, where σ_α is the permutation of $Q_8 \times C_2^n$ that inverts every element of $\{\pm\alpha\} \times C_2^n$ and fixes every other element.

The following definition will be used in Section 2.7.

Definition 1.20 ([14, p. 89])**.** A group G is a **Sylow cyclic group** if, for every prime p, the Sylow p-subgroups of G are cyclic.

Finally we conclude this section with a very important definition that will be used throughout the thesis.

Definition 1.21 ([1, p. 97])**.** A generating set C for a group G is called a **minimal generating set for** G if for all $c \in C$ we have that $\langle C \backslash \{c\} \rangle \neq G$.

We use both wreath products and semi-direct products in this thesis. For those unfamiliar with these definitions see [10, p. 81, 88] or [4, p. 44, 46].

Chapter 2

Background

The results of this Chapter are based on [5, 11, 13, 14].

The recent work on CCA groups has produced the following major results that will be used in the remaining chapters:

- There is a group of order n that is not CCA if and only if $n \geq 8$, and n is divisible by either 4, 21, or a number of the form $p^q q$, where p and q are primes (not necessarily distinct) and p is odd (Corollary 2.24).

- An abelian group is not CCA if and only if it has a direct factor isomorphic to either $C_4 \times C_2$ or a group of the form $C_{2^k} \times C_2 \times C_2$, for some $k \geq 2$ (Proposition 2.12).

- Every non-CCA group of odd order has a section that is isomorphic to either the nonabelian group of order 21 or is a semi-wreath product of certain groups (Theorem 2.22).

- If $G \times H$ is CCA, then G and H are both CCA. The converse is not always true, but it is true if $gcd(|G|,|H|) = 1$ (Proposition 2.9 and 2.10).

- A finite simple group is CCA if and only if it has no element of order four (see [13]).

The proofs and details of these results will be looked at in depth in the coming sections.

2.1 Non-CCA Groups

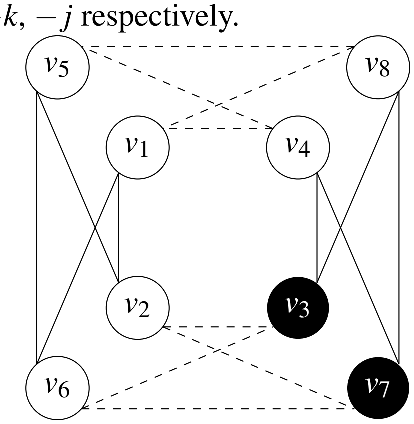
In this section we show a couple of small examples of groups that are non-CCA. First we notice that for an affine function to fix the identity, it must be an automorphism of the group. This is because if there is some left translate by a non-identity element it would move the identity element. So, if we have that $Cay(G,C)$ is CCA, then every colour-preserving automorphism is affine and thus from above we must have that every colour-preserving automorphism that fixes the identity is an automorphism of the group. More precisely:

Remark 2.1. A Cayley graph $Cay(G,C)$ is CCA if and only if, for every colour-preserving automorphism φ of $Cay(G,C)$ with $\varphi(e) = e$, we have that $\varphi \in Aut(G)$ (see [11, Rem. 2.1]).

This fact is a consequence of Cayley graphs being vertex-transitive, and we can make a similar statement with strongly CCA in place of CCA. We now give the first two examples of non-CCA groups.

Example 2.2 ([11, Example. 2.2])**.** $C_4 \times C_2$ and Q_8 (the quaternion group) are non-CCA.

Proof. For $G = Q_8$ consider the connection set $C = \{\pm i, \pm j\}$. Below is a graph isomorphic to $Cay(Q_8, \{\pm i, \pm j\})$ with nodes v_1, v_2, v_3, v_4, v_5, v_6, v_7, v_8 replaced with 1, i, k, j, -1, $-i$, $-k$, $-j$ respectively.



The dashed edges correspond to the edges formed by $\pm j$ and the solid ones correspond to $\pm i$. Consider the automorphism φ that swaps the vertices $k, -k$: this corresponds to flipping the two black vertices in the above picture. We can see that φ preserves the edge types and is thus a colour-preserving automorphism, but since φ fixes the identity 1, by Remark 2.1 φ must be in $Aut(Q_8)$ but this is not the case (since $\{i, j\}$ generate Q_8 and are fixed pointwise by φ but φ is not the identity function).

Similarly if we consider $G = C_4 \times C_2$ and the connection set $C = \{\pm(1,0), \pm(1,1)\}$ we have that $Cay(C_4 \times C_2, \{\pm(1,0), \pm(1,1)\})$ is again isomorphic to the above graph with nodes v_1, v_2, v_3, v_4, v_5, v_6, v_7, v_8 replaced with $(0,0)$, $(1,0)$, $(2,1)$, $(1,1)$, $(2,0)$, $(3,0)$, $(0,1)$, $(3,1)$ respectively. The dashed edges correspond to $\pm(1,1)$ and the solid to $\pm(1,0)$. We can see similarly that by swapping $(0,1)$ and $(2,1)$ we get an automorphism of the graph that fixes $(0,0)$ but is not an automorphism of $C_4 \times C_2$ (again it is not the identity but fixes $(1,0)$ and $(1,1)$ pointwise, and these generate $C_4 \times C_2$).

We present a second method to see that the automorphism in both cases is not an automorphism of the group (this idea is extended in the next proposition). A group automorphism has the property that the elements fixed by the automorphism form a subgroup of the original group. Thus if more than half the elements are fixed by an automorphism this implies that the automorphism must be the identity (using the fact that the order of a subgroup divides the order of the group). Thus since both automorphisms presented above fix all but two elements, six elements are fixed and thus to be an automorphism of the original group it would have to be the identity (which it is not). □

The ideas used in this proof can be generalized. This leads us to our next proposition giving a construction that can prove that a group is not CCA. As seen later in this section, this leads to several examples of non-CCA groups.

Proposition 2.3 ([11, Prop. 2.5])**.** *Suppose there is a generating set C of G, an element τ of G, and a subset T of C, such that:*

- $\tau^2 = e$,
- *for each element $c \in C$, $\tau c \tau \in \{c, c^{-1}\}$,*
- $t^2 = \tau$ *for all $t \in T$,*
- *the subgroup $\langle (C \backslash T) \cup \{\tau\} \rangle \neq G$, and*
- $|G : \langle (C \backslash T) \cup \{\tau\} \rangle| > 2$ *or* $\tau \notin Z(G)$

Then G is not CCA.

Proof. Let $H = \langle (C \backslash T) \cup \{\tau\} \rangle$. Since G is generated by C but H is not all of G we have that there exists $t_0 \in T$ such that $t_0 \notin H$. Consider the function φ from G to G defined by $\varphi(g) = g$ if $g \notin t_0H$ and $\varphi(g) = g\tau$ if $g \in t_0H$. We first prove that φ is a colour-preserving automorphism of $Cay(G,C)$. Our goal afterwards (to show G is not CCA) will be achieved by showing that φ is not affine. Since φ fixes the identity of G (since the identity is in H), by Remark 2.1 this means we will show that φ is not an automorphism of G.

Clearly φ fixes edges between two vertices not in t_0H so it fixes their colour as well. Suppose $w \in t_0H$ and let c be any element of C such that $wc \in t_0H$, then $\varphi(wc) = wc\tau = w\tau c^{\pm 1} = \varphi(w)c^{\pm 1}$ using the assumption that $\tau c \tau = c^{\pm 1}$. This proves (from Definition 1.6) that φ preserves the colour of edges that are inside t_0H. Lastly we must show that the colour of edges is preserved when one vertex is in t_0H and one vertex is not.

Suppose there are adjacent vertices $w \in t_0H$ and $g \notin t_0H$. Thus there exists $c \in C$ such that $wc = g$. If c was in $C \backslash T$ then $c \in H$ and this would mean $wc \in t_0H$, so we may assume $c \in T$. Since φ fixes g we must prove that $\varphi(w)$ has an edge of colour c to g (we use this terminology loosely but the meaning should be clear). By our definitions there is an edge of colour c from $\varphi(w)$ to $\varphi(w)c^{\pm 1}$. We notice $\varphi(w)c^{-1} = w\tau c^{-1}$ and from our assumption since $c \in T$ we have that $c^2 = \tau$ giving us $w\tau c^{-1} = wc^2c^{-1} = wc = g$ and thus as desired we have an edge of colour c from $\varphi(w)$ to g. Therefore φ is a colour-preserving automorphism.

All we have left to prove is that φ is not affine. We have two cases to consider.

Case 1: $|G : H| > 2$

In this case we have that φ fixes more then half of the elements of G. Recalling Example 2.2 this implies that if φ was an automorphism of G it must be the identity. Since it is not the identity this implies that φ is not an automorphism of G as desired.

Case 2: $|G : H| = 2$

By our assumption this means that τ is not in the center of G, so $\exists g \in G$ such that $\tau g \neq g\tau$. From our third assumption for $t \in T$ we have that $\tau t = t^3 = t\tau$ and thus τ commutes with elements of T. All elements of G can be written in the form th for $t \in T$ and $h \in H$

since H contains $C\backslash T$ and C generates G. So without loss of generality this means we can take $g \in H$ since τ commutes with the elements of T. (We use guidance from [11] to finish this proof.) Suppose towards a contradiction that φ is an automorphism of G. We notice from our third assumption that $t_0^{-1} = t_0^3 = t_0\tau$ and since $\tau \in H$ we have $t_0\tau \in t_0H$ which gives us that $t_0^{-1} \in t_0H$. Using our assumptions we get the following (each step is explained in more detail following the calculations):

$$t_0^{-1}gt_0 = \varphi(t_0^{-1}gt_0) = \varphi(t_0^{-1})g\varphi(t_0) = t_0^{-1}\tau g t_0 \tau \neq t_0^{-1}g\tau t_0\tau = t_0^{-1}gt_0.$$

The first equality is since $t_0^{-1}gt_0 \notin t_0H$ and thus φ fixes $t_0^{-1}gt_0$. The second equality is from our assumption that φ is an automorphism and it fixes g since $g \notin t_0H$. The third equality is since $t_0, t_0^{-1} \in t_0H$. The next inequality is due to our assumption that τ does not commute with g, and the last equality is due to τ commuting with t_0 and $\tau^2 = e$. This calculation is a contradiction so we must have φ not an automorphism of the group.

□

We use Proposition 2.3 to summarize some of our examples of non-CCA groups.

Corollary 2.4 ([11, Cor. 2.8])**.** *The following groups are not CCA:*

1. $C_4 \times C_2$,
2. $C_{2^k} \times C_2 \times C_2$, *for any* $k \geq 2$,
3. Q_8
4. *every generalized dicyclic group except* C_4, *and*
5. *every semidihedral group.*

Proof. For each we will apply Proposition 2.3.

(1) Consider $\tau = (2,0)$ and $C = T = \{\pm(1,0), \pm(1,1)\}$. We fulfill the requirements since $(2,0)+(2,0) = (0,0)$, $C_4 \times C_2$ is abelian (and thus τ commutes with all elements),

$(1,0)+(1,0)=(2,0)=(1,1)+(1,1)$ and lastly $|G:\langle (C\backslash T)\cup\{\tau\}\rangle| = |G:\langle (2,0)\rangle| = |G:\{(0,0),(2,0)\}| = 4$ which satisfies the last two requirements.

(2) Take τ to be $(2^{k-1},0,0)$ with $C=\{(1,0,0),(2^{k-2},1,0),(2^{k-2},0,1)\}$ and consider $T=\{(2^{k-2},1,0),\,(2^{k-2},0,1)\}$. This satisfies all the requirements of the proposition since $(2^{k-1},0,0)+(2^{k-1},0,0)=(0,0,0)$, $C_{2^k}\times C_2\times C_2$ is abelian (so τ commutes with all elements), $(2^{k-2},1,0)+(2^{k-2},1,0)=(2^{k-1},0,0)=(2^{k-2},0,1)+(2^{k-2},0,1)$. The last two properties are satisfied since $|G:\langle (C\backslash T)\cup\{\tau\}\rangle| = |G:\langle\{(1,0,0)\}\rangle| = \frac{2^{k+2}}{2^k}=4$.

(3) Consider $\tau=-1$ and $C=T=\{\pm i,\pm j\}$. This satisfies all the properties since $(-1)^2=1$, $(\pm i)^2=i^2=-1=j^2=(\pm j)^2$. We also have that -1 commutes with all elements of Q_8 and similar to the above examples $|G:\langle (C\backslash T)\cup\{\tau\}\rangle| = |G:\langle -1\rangle| = 4$.

(4) Using Definition 1.11 for $Dic(y,A)$, take $\tau=y$ and let $C=T=\{xa : a\in A\}=xA$. Then $\tau^2=y^2=e$ since y is an involution. Let $c\in C$ be arbitrary, then we have $c=xa$ for some $a\in A$. So

$$\tau c\tau = yxay = x^3ax^2 = x^{-1}axx = a^{-1}x = xa = c$$

thus satisfying second property needed for Proposition 2.3. The third property is satisfied since

$$c^2=(xa)^2=xaxa=xxa^{-1}a=x^2=y=\tau$$

for all $c\in C=T$. Finally the last property is satisfied since $|\langle (C\backslash T)\cup\{\tau\}\rangle| = |\{\tau\}| = 2$ and since $Dic(y,A)\ncong C_4$ we have $|Dic(y,A)|>4$ thus $|Dic(y,A):\langle\{\tau\}\rangle|>2$ as desired.

(5) Using Definition 1.12 for $SemiD_{16n}$, take $\tau=a^{4n}$ and let $T=\{ax,xa^{-1}\}$ and $C=\{x,ax,xa^{-1}\}$. Now to satisfy the second property, consider $c\in C$ to be arbitrary. For the two cases $c\in\{x,ax\}$ let $c=a^m x$ with $m\in\{0,1\}$. Then

$$\tau c\tau = \tau a^m x\tau = a^{4n}a^m xa^{4n} = a^{4n+m}a^{4n-1}xa^{4n-1} = a^{m-1}ax = a^m x.$$

Now consider $c = xa^{-1}$:

$$\tau c\tau = \tau xa^{-1}\tau = a^{4n}xa^{-1}a^{4n} = a^{4n-1}(ax)a^{4n-1} = a^{4n-1}xa^{4n-1}a^{4n-1} = xaa^{-2} = xa^{-1}$$

giving us that τ centralizes C. Now let $t \in T$ be arbitrary, for the case $t = ax$ we have

$$t^2 = (ax)^2 = axax = aa^{4n-1}xx = a^{4n}x^2 = \tau e = \tau$$

and for the case $t = xa^{-1}$ we have

$$t^2 = (xa^{-1})^2 = xa^{-1}xa^{-1} = xxa^{-(4n-1)}a^{-1} = x^2a^{4n+1-1} = ea^{4n} = \tau$$

so the third property is satisfied. Now

$$|SemiD_{16n} : \langle (C \backslash T) \cup \{\tau\} \rangle| = |SemiD_{16n} : \langle \{x, \tau\} \rangle| = \frac{16n}{4} = 4n > 2$$

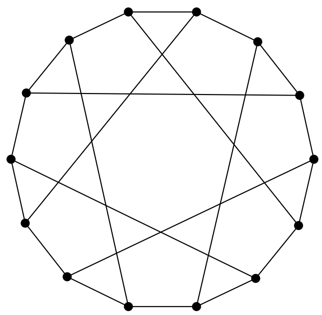
as desired. □

Proposition 2.5 ([14, Prop. 4.6])**.** *Let X be a connected bipartite G-edge-regular graph. If H is a group of automorphisms of X such that:*

- *$G \leq H$,*
- *the orbits of H on the vertex-set of X are exactly the biparts, and*
- *for every vertex v of X, either $G_v^{N(v)} = H_v^{N(v)}$ or $(G_v^{N(v)}, H_v^{N(v)})$ is a complete colour pair,*

then H is a colour-preserving group of automorphisms of $\mathcal{L}(X)$ viewed as a Cayley graph on G.

Example 2.6 ([14, Example. 4.8])**.** The unique nonabelian group of order 21 is not CCA.



Proof.

Let X be the Heawood graph (the graph seen above) and let H be the subgroup of $Aut(X)$ that preserves the bipartitions. It can be seen that $H \cong PSL(2,7)$ and H contains an edge-regular subgroup G (isomorphic to the nonabelian group of order 21). Thus $\mathcal{L}(X)$ can be viewed as a Cayley graph on G.

We also have that for every vertex v of X, $G_v^{N(v)} \cong C_3$ and $H_v^{N(v)} \cong D_3$. Since (C_3, D_3) is a complete colour pair we can apply Proposition 2.5 and say that H is a colour-preserving group of automorphisms of $\mathcal{L}(X)$ (viewed as a Cayley graph on G). But G is not normal in H, so there exists an element $h \in H$ such that $hG \neq Gh$. Since H is a colour-preserving group of automorphisms of $\mathcal{L}(X)$ that means h preserves its colours, but h is not an affine function of G. Therefore $\mathcal{L}(X)$ is a non-CCA graph of G and so G (the nonabelian group of order 21) is non-CCA. □

We will see that Example 2.6 is useful in Section 2.5 and 2.7. Lastly we have one more example, involving wreath products.

Proposition 2.7 ([14, Prop. 3.1])**.** *Let H be a permutation group of a set Ω, G a group. If*

- *there is an inverse-closed generating set C for G and a non-identity bijection $\tau : G \to G$, such that τ fixes e, and $\tau(gc) = \tau(g)c^{\pm 1}$ for every $g \in G$ and every $c \in C$, and*
- *either H is nontrivial or $\tau \notin Aut(G)$,*

then $G \wr_\Omega H$ is non-CCA.

Proposition 2.7 has multiple applications, some of which can be seen in [14]. Another application is the following example.

Example 2.8 ([11, Example. 2.4])**.** The wreath product $C_m \wr C_n$ is not CCA whenever $m \geq 3$ and $n \geq 2$.

2.2 Direct and Semidirect Products

For a group G that is a direct product of two other groups G_1 and G_2, it is natural to check what conditions cause G to be a non-CCA group. It will be shown in the next proposition that if either G_1 or G_2 is not CCA, then G is not CCA.

Proposition 2.9 ([11, Prop. 3.1])**.** *If G_1 is not (strongly) CCA, and G_2 is any group, then $G_1 \times G_2$ is not (strongly) CCA.*

Proof. Since G_1 is not strongly CCA, $\exists C_1$ a generating set of G_1 with a colour-permuting automorphism φ of $Cay(G_1, C_1)$ that is not affine. By the definition of colour-permuting automorphism this means that for all $g_1 \in G_1$ and $c_1 \in C_1$ we have $\varphi(g_1 c_1) = \varphi(g_1)\pi(c_1)^{\pm 1}$ for some π a permutation of C_1. Let C_2 be any generating set for G_2 and consider the Cayley graph $Cay(G_1 \times G_2, C)$ where $C = \{(c_1, e_{G_2}) : c_1 \in C_1\} \cup \{(e_{G_1}, c_2) : c_2 \in C_2\}$. It is not hard to see that C is a generating set for $G_1 \times G_2$ so $Cay(G_1 \times G_2, C)$ is connected.

Our goal is to prove that $Cay(G_1 \times G_2, C)$ has a colour-permuting automorphism that is not affine. We consider the function φ' defined by $\varphi'(g_1, g_2) = (\varphi(g_1), g_2)$. Let $(g_1, g_2) \in G_1 \times G_2$, $c_1 \in C_1$ and $c_2 \in C_2$ all be arbitrary. Then:

$$\varphi'((g_1, g_2)(c_1, e_{G_2})) = (\varphi(g_1 c_1), g_2) = (\varphi(g_1)\pi(c_1)^{\pm 1}, g_2) = \varphi'(g_1, g_2)(\pi(c_1), e_{G_2})^{\pm 1}, \text{ and}$$

$$\varphi'((g_1, g_2)(e_{G_1}, c_2)) = (\varphi(g_1), g_2 c_2) = \varphi'(g_1, g_2)(e_{G_1}, c_2)$$

Therefore φ' is a colour-permuting automorphism of $Cay(G_1 \times G_2, C)$, and it is not affine since if we restrict φ' to G_1 it is not affine.

The proof for colour-preserving automorphism follows exactly the same argument replacing π with the identity map. $\square$

Proposition 2.9 says that if $G_1 \times G_2$ is (strongly) CCA then both G_1 and G_2 must also be (strongly) CCA. The converse is not always true: for example C_4 and C_2 are both CCA, but as we saw previously, $C_4 \times C_2$ is not CCA. But we can improve Proposition 2.9 with the following result, showing that if the order of the groups are coprime then the converse is true.

Proposition 2.10 ([11, Prop. 3.2])**.** *If $|G_1|$ and $|G_2|$ are coprime then $G_1 \times G_2$ is (strongly) CCA if and only if G_1 and G_2 are both (strongly) CCA.*

Proof. $(\Rightarrow)$ Proposition 2.9.

$(\Leftarrow)$ Suppose that G_1 and G_2 are both strongly CCA and let C be any generating set of $G_1 \times G_2$. Define $\pi_i : G_1 \times G_2 \to G_i$ to be the natural projection for $i = 1,2$. Let k be a multiple of $|G_2|$ such that $k \equiv 1 \pmod{|G_1|}$. Such a k can be found since $\gcd(|G_1|,|G_2|) = 1$.

For $(g_1,g_2) \in G_1 \times G_2$ we see that $(g_1,g_2)^k = (g_1^k,g_2^k) = (g_1,e_{G_2})$. Therefore (with some abuse of notation) for $g \in G_1 \times G_2$, $g^k = \pi_1(g)$. Suppose $c \in C$ is arbitrary and let $c_0 \in C$ be the 'colour' that c is permuted to, more formally $c_0 = \varphi(c)$. For $g \in G_1 \times G_2$ we have:

$$\varphi(g\pi_1(c)) = \varphi(gc^k) = \varphi(g)c_0^{\pm k} = \varphi(g)\pi_1(c_0)^{\pm 1} \in \varphi(g)G_1 \tag{2.1}$$

Consider $g_1 \in G_1$ arbitrary and $g_2 \in G_2$. Since C generates $G_1 \times G_2$, $\exists c_1,\ldots,c_m \in C$ such that $g_1 = \pi_1(c_1)\ldots\pi_1(c_m)$ and so by applying (2.1) m times we get that:

$$\varphi(g_1g_2) = \varphi(g_2g_1) = \varphi(g_2\pi_1(c_1)\ldots\pi_1(c_m)) \in \varphi(g_2)G_1 = G_1\varphi(g_2)$$

Since g_1 was arbitrary we have that $\varphi(G_1g_2)$ is contained in $G_1\varphi(g_2)$. Moreover, if we consider $\varphi_2(g_2) = \pi_2(\varphi(g_2))$ (a well-defined permutation of G_2) we get $\varphi(G_1g_2) = G_1\varphi_2(g_2)$.

Repeating a similar argument we can find φ_1 a permutation of G_1 with the property that $\varphi(g_1,g_2) = (\varphi_1(g_1),\varphi_2(g_2))$. Notice that (2.1) says that φ_1 is a colour-permuting automorphism of $Cay(G_1, \pi_1(C))$ and thus must be an automorphism of G_1 since G_1 is strongly CCA. Similarly φ_2 is a automorphism of G_2.

Thus to show φ is an automorphism of $G_1 \times G_2$, let $(g_1, g_2), (g_1', g_2') \in G_1 \times G_2$ be arbitrary. Then

$$\begin{aligned}\varphi((g_1,g_2)(g_1',g_2')) &= (\varphi_1(g_1g_1'), \varphi_2(g_2g_2')) \\ &= (\varphi_1(g_1)\varphi_1(g_1'), \varphi_2(g_2)\varphi_2(g_2')) \\ &= (\varphi_1(g_1), \varphi_2(g_2))(\varphi_1(g_1'), \varphi_2(g_2')) \\ &= \varphi(g_1,g_2)\varphi(g_1',g_2')\end{aligned}$$

In the case where G_1, G_2 are CCA instead of strongly CCA we use the same proof, with $c_0 = c^{\pm 1}$. □

A result using the same ideas used in Example 2.8 leads us to the following proposition.

Proposition 2.11 ([11, Prop. 3.3])**.** *Suppose $G = H \rtimes K$ is a semidirect product, and also that $Cay(H, C_0)$ is a connected Cayley graph of H, such that*

- *C_0 is invariant under conjugation by every element of K, and*
- *there is a colour-preserving automorphism φ_0 of $Cay(H, C_0)$, such that either*
  - *φ_0 is not affine, or*
  - *$\varphi_0(e) = e$, and there exists $c \in C_0$ and $k \in K$, such that $\varphi_0(k^{-1}sk) \neq k^{-1}\varphi_0(s)k$.*

Then G is not CCA.

2.3 Abelian Groups

It is interesting for us to consider abelian groups as a natural family of groups that we can completely classify using these ideas. In this section we present a proposition that gives us the exact conditions needed for an abelian group to be non-CCA. These conditions relate to the two groups we have previously looked at ($C_4 \times C_2$ and $C_{2^k} \times C_2 \times C_2$) and it says that the only time that an abelian group is non-CCA is exactly when it has a direct factor isomorphic to one of these groups. Afterwards, we get a simple corollary that is a consequence of the coming proposition and Proposition 2.9.

Proposition 2.12 ([11, Prop. 4.1])**.** *For an abelian group G, the following are equivalent:*

1. *G has a direct factor that is isomorphic to either $C_4 \times C_2$ or a group of the form $C_{2^k} \times C_2 \times C_2$, for any $k \geq 2$*
2. *G is not CCA*
3. *G is not strongly CCA*

Corollary 2.13 ([11, Cor. 4.2])**.** *There is a non-CCA abelian group of order n if and only if n is divisible by 8.*

2.4 Generalized Dihedral Groups

Since we know exactly when an abelian group is (strongly) CCA, we consider looking at groups that are constructed from abelian groups. In this section we will look at the generalized dihedral groups and determine when they are (strongly) CCA.

Lemma 2.14 ([11, Lem. 5.2])**.** *Suppose D is the generalized dihedral group over an abelian group A, and also that φ is a colour-permuting automorphism of a connected Cayley graph $Cay(D,C)$, such that $\varphi(e) = e$. If A is strongly CCA, and $\varphi(C \cup A) = C \cup A$, then φ is an automorphism of D.*

Proposition 2.15 ([11, Prop. 5.3])**.** *The generalized dihedral group D over an abelian group A is CCA if and only if A is CCA.*

From Proposition 2.12 we can notice that since cyclic groups cannot have a direct factor isomorphic to $C_4 \times C_2$ or $C_{2^k} \times C_2 \times C_2$ we get that cyclic groups are (strongly) CCA. Thus by Proposition 2.15 we get the following simple corollary.

Corollary 2.16 ([11, Cor. 5.4])**.** *Every dihedral group is CCA.*

We can also do better and look at the exact requirements needed for a generalized dihedral group to be strongly CCA. This leads us to the following lemma which helps prove the next proposition.

Lemma 2.17 ([11, Lem. 5.5])**.** *If C is a generating set of a group H, and σ is a nontrivial automorphism of H, such that $\sigma(c) \in \{c, c^{-1}\}$ for all $c \in C$, then the group $G = (H \rtimes \langle\sigma\rangle) \times C_2$ is not strongly CCA.*

Proposition 2.18 ([11, Prop. 5.6])**.** *The generalized dihedral group over an abelian group A is strongly CCA if and only if either:*

- *A does not have C_2 as a direct factor, or*
- *A is an elementary abelian 2-group.*

2.5 Groups of Odd Order

We now will be considering the cases where the order of G is odd.

Lemma 2.19 ([11, Lem. 6.3])**.** *$\mathcal{A}_e^0$ is a 2-group (recall Notation 1.2).*

Proof. Suppose $\varphi \in \mathcal{A}_e^0$, then φ is a colour-preserving automorphism of $Cay(G,C)$ that fixes e. Consider any cycle $\mathscr{C}$ that contains edges of only one colour with $e \in \mathscr{C}$. Since e is fixed by φ, then either $\mathscr{C}$ is fixed or reflected by φ. In either case φ^2 fixes $\mathscr{C}$ and so since every vertex with distance one away from e is on some cycle (containing only one edge colour), φ^2 fixes all vertices of distance 1 away from e. Since there was nothing special about e being fixed we can use this argument again using the neighbours of e to show that φ^{2^2} fixes all vertices of distance 2 away from e. By repeating this process enough times this shows that φ^{2^m} fixes all vertices with m large enough, which shows that the order of φ is a power of 2. Since φ was arbitrary this means that $\mathcal{A}_e^0$ is a 2-group. □

Our next result says that the CCA and strongly CCA properties are equivalent for groups of odd order.

Proposition 2.20 ([11, Prop. 6.4]). *Let $Cay(G,C)$ be a connected Cayley graph on a group G of odd order. If every colour-preserving automorphism of $Cay(G,C)$ is affine, then every colour-permuting automorphism is affine.*

Proof. Let $\mathcal{A}^*$ be the set of all colour-permuting automorphisms of $Cay(G,C)$. We can see from Remark 1.8 that if a permutation is affine, then it normalizes $\widehat{G}$ so if we can prove that $\widehat{G} \triangleleft \mathcal{A}^*$ then that means that every permutation of $\mathcal{A}^*$ normalizes $\widehat{G}$ and thus are all affine which gives us that G is strongly CCA.

Since G is CCA this implies that $\widehat{G} \triangleleft \mathcal{A}^0$. Moreover we will show that we can get $\widehat{G} \operatorname{char} \mathcal{A}^0$ which will help finish the proof. By the definition of $\mathcal{A}^0$ and $\widehat{G}$ we can see that $\mathcal{A}^0 = \widehat{G}\mathcal{A}_e^0$. Also by our definition of $\widehat{G}$ we get that $|G| = |\widehat{G}|$ and so $|\widehat{G}|$ is odd. As proven in Lemma 2.19 we have that $|\mathcal{A}_e^0|$ is a power of 2 and so this means that $\widehat{G}$ is the unique largest subgroup of odd order in $\mathcal{A}^0$. Thus since $\widehat{G}$ is unique, every automorphism of $\mathcal{A}^0$ must fix $\widehat{G}$ setwise. So by Definition 1.15 this means $\widehat{G} \operatorname{char} \mathcal{A}^0$.

Now, by Lemma 1.16, $K \operatorname{char} \mathrm{H} \triangleleft \mathrm{G}$ implies $K \triangleleft G$, so all we must show is that $\mathcal{A}^0 \triangleleft \mathcal{A}^*$ (since it is clear that $\mathcal{A}^0$ is a subgroup of $\mathcal{A}^*$). This is easy to see since $\mathcal{A}^*$ permutes the colours and $\mathcal{A}^0$ fixes them and so $\mathcal{A}^0$ is the kernel of the action of permuting the colours. Thus since the kernel of a homomorphism is normal, we get our desired result. □

Definition 2.21. Let G be a group. For any subgroups H,K of G, such that $K \triangleleft H$, the quotient H/K is said to be a section of G.

The follow theorem gives us an indication of what a non-CCA group of odd order looks like. This uses Example 2.6 with the nonabelian group of order 21.

Theorem 2.22 ([11, Thm. 6.8])**.** *Any non-CCA group of odd order has a section that is isomorphic to either:*

- *A semi-wreathed product $A \wr_\alpha C_n$, where A is a nontrivial, elementary abelian group of odd order and $n > 1$, or*
- *the unique nonabelian group of order 21.*

The following Lemma gives us some restrictions on the set C when determining the (strongly) CCA property. Our algorithm does not implement this but it could be used to reduce the search space.

Lemma 2.23 ([11, Lem. 6.11])**.** *To prove a group G is (strongly) CCA, it suffices to consider only the connected Cayley graphs $Cay(G,C)$, such that every element of C has prime-power order.*

The next corollary summarizes several results of [11]. We have used it to restrict the orders on which we run our program, to those for which non-CCA groups exist.

Corollary 2.24 ([11, Cor. 6.13])**.** *The following are equivalent*

- *There is a group of order n that is not CCA*
- *There is a group of order n that is not strongly CCA*
- *$n \geq 8$, and n is divisible by either 4, 21, or a number of the form $p^q q$, where p and q are primes (not necessarily distinct) and p is odd*

2.6 Groups of Small Order

In this section we look at all groups that have order less than 32 and see whether or not they are CCA. This section is going to be useful in Chapter 4 where we try to classify all groups up to order 200 (except orders 128 and 192). These results will help us cross-check our output for groups of order up to 32.

Proposition 2.25 ([11, Prop. 7.1])**.** *An abelian group of order less than 32 is not (strongly) CCA if and only if it is either*

- $C_2 \times C_4$,
- $C_2 \times C_2 \times C_4$, *or*
- $C_2 \times C_3 \times C_4$.

Proposition 2.26 ([11, Prop 7.2])**.** *The only groups that are not (strongly) CCA, and whose order is less than 32 and not divisible by 4 are:*

- $C_3 \wr C_2 \cong D_6 \times C_3$, *and*
- *the unique nonabelian group of order 21.*

Proposition 2.27 ([11, Prop 7.3])**.** *The only nonabelian groups that are strongly CCA and whose order is less than 32 and is divisible by 4 are:*

- *the dihedral groups* D_8, D_{16}, D_{24},
- *the alternating group* A_4,
- $C_8 \wr C_2$ *in which* $a^{-1}xa = x^5$ *for* $x \in C_8$ *and* $\langle a \rangle = C_2$, *and*
- $D_8 \times C_3$, $A_4 \times C_2$ *and* $C_3 \rtimes C_8$ *in which* C_8 *inverts* C_3.

Furthermore, the only groups of order less than 32 that are CCA, but not strongly CCA, are:

- *the dihedral groups* D_{12}, D_{20}, D_{28}, *and*
- *the generalized dihedral group* $D_{12} \times C_2$.

2.7 Sylow Cyclic Groups with Order not divisible by four

We now look at our last example of families of groups that have been studied. The following theorem helps us understand the structure of Sylow cyclic groups (recall Definition 1.20) whose order is not divisible by four that admit non-CCA Cayley graphs. It is a simplified version of [14, Thm. 5.1].

Theorem 2.28 ([14, Thm. 5.1]). *Let G be a be a Sylow cyclic group whose order is not divisible by four and that is non-CCA. Then*

- $G = F \times H$, *or*
- $G = (F \times H) \rtimes C_2$

where $|H|$ is odd and F is the nonabelian group of order 21.

The next two theorems are in some sense converse to each other. In the first theorem if we have a non-CCA Cayley graph on a Sylow cyclic group whose order is not divisible by four, then there is a connected Cayley graph on a smaller group that is not CCA. The second theorem shows that if we have this 'condensed' Cayley graph with a couple of properties (including not CCA) then the 'expanded' Cayley graph is non-CCA.

Theorem 2.29 ([14, Thm. 5.2]). *Let G be a Sylow cyclic group whose order is not divisible by four, let $Cay(G,C)$ be a connected non-CCA graph and let $A = \mathcal{A}^0$, the colour preserving automorphisms of $Cay(G,C)$. Using notation from Theorem 2.28 write $A = (T \times J) \rtimes R$ and $G = (F \times H) \rtimes R$. Let r be the generator of R, let $Y = S \backslash (F \cup (H \rtimes R))$ and let*

$$X = Cay(F \rtimes R, (F \cap S) \cup \{r\} \cup \{s^2 : s \in Y\}).$$

Then

- *X is connected and non-CCA.*
- $Y \subseteq \{fz : f \in F, z \in Hr, |f| = 3, |z| = 2\}$, *and*

- *if* $Y \neq \emptyset$*, then* $|R| = 2$*, and* T *commutes with* R*.*

Theorem 2.30 ([14, Thm. 5.2])**.** *Let* G *be a Sylow cyclic group whose order is not divisible by four such that* $G = (F \times H) \rtimes R$ *where* F *is the nonabelian group of order 21,* R *is a Sylow 2-subgroup of* G*, and* F *and* H *are normal in* G*. Let* r *be the generator of* R*, let* C *be a generating set for* G*, let* $Y = S \backslash (F \cup (H \rtimes R))$*, and let*

$$X = Cay(F \rtimes R, (F \cap S) \cup \{r\} \cup \{s^2 : s \in Y\}).$$

If

- X *is connected and non-CCA*
- $Y \subseteq \{fz : f \in F, z \in Hr, |f| = 3, |z| = 2\}$*, and*
- *if* $Y \neq \emptyset$*, then* $|R| = 2$*, and* F *commutes with* R*,*

then $Cay(G,C)$ *is connected and non-CCA.*

See [14] to see what the possible ‘condensed’ graphs are, one of which is similar to Example 2.6.

Putting Theorem 2.30 together with the fact that F (the nonabelian group of order 21) is non-CCA and the direct product results (Proposition 2.9), we see that any group satisfying Theorem 2.28 is non-CCA. Thus we have a complete characterization of Sylow cyclic groups whose order is not divisible by four, according to whether or not they are CCA.

Chapter 3

Algorithms to determine CCA groups

As discussed in Section 2.6 we hope to expand the number of groups that we know are or are not CCA. A new program was developed to verify whether or not a group is CCA. The program is the main contribution of this thesis and forms the basis of the thesis. It uses both GAP [8] and Sage [17]. In this chapter we explain the algorithm(s) used by the program and how it determines whether or not a group or graph is CCA. After giving all the background knowledge needed we will explain the algorithm and give some arguments as to why it works. In later sections we will break down the larger algorithm into smaller pieces and explain each piece in more detail.

In this section we describe the algorithm using pseudo code. The actual code can be found in Appendix A.

3.1 Background and general approach of the algorithms

Recalling Definition 1.7, for a group to be CCA means that every connected Cayley graph on that group must also be a CCA graph. So one way for our program to solve this problem is to look at every connected Cayley graph of a group to determine whether the group is CCA. Lemma 1.10 then tells us that to find each connected Cayley graph we can reduce to considering $Cay(G,C)$ for those C that generate G. Since the number of generating sets of a group can be large we use the following lemma to help us reduce the number of generating sets we need to look at.

Lemma 3.1. *Let C be a minimal generating set of G and let $C' \supseteq C$. If $Cay(G,C')$ is not*

CCA then $Cay(G,C)$ is not CCA.

Proof. If φ is a colour-preserving automorphism of $Cay(G,C')$ then it also must also be a colour-preserving automorphism of $Cay(G,C)$. Assume $Cay(G,C')$ is not CCA, then there exists a colour-preserving automorphism φ that is not an affine function on G. From above, φ would also be a colour-preserving automorphism of $Cay(G,C)$, and φ is not an affine function on G. Thus $Cay(G,C)$ is not CCA. $\square$

This Lemma is known by experts but has not been published. Lemma 3.1 tells us that we only need to look at Cayley graphs that are formed by minimal generating sets to check for the CCA property in groups. So we have two main algorithms that need to be considered. The first algorithm is given a group, determine all unique minimal generating sets of that group (up to group automorphism). The second algorithm is given a group and a minimal generating set, determine whether the Cayley graph generated by the two is CCA. Combining those two together, for each group we find all minimal generating sets and see if all the corresponding Cayley graphs are CCA. If any of the graphs are not CCA then the group is not CCA.

By Remark 2.1 we will only need to check colour-preserving automorphisms of the Cayley graph that fix the identity. Another useful remark for our algorithm is the following.

Remark 3.2. If $\mathcal{A}^0$ is the group of colour-preserving automorphisms of $Cay(G,C)$, then $Cay(G,C)$ is CCA if $|\mathcal{A}^0| = |G|$.

The reason that Remark 3.2 is true is because recalling Chapter 1, all elements of $\widehat{G} \cong G$ (recall Notation 1.2, this is the set of left translations of $\mathcal{A}^0$) are in $\mathcal{A}^0$. Thus if $|\mathcal{A}^0| = |G|$ then $\mathcal{A}^0 = \widehat{G}$. Using Remark 2.1 with the fact that the only element of $\mathcal{A}^0$ that fixes the identity is the identity itself gives us that all elements of $\mathcal{A}^0$ that fix the identity are elements of $Aut(G)$.

3.2 Pseudocode and explanation for the algorithms

We start with the CCA Algorithm (Algorithm 1) which determines whether or not a given group is CCA. Algorithm 1 relies on Algorithm 2 (which determines whether a function on G is an element of $Aut(G)$) and Algorithm 3 (which finds all minimal generating sets of a group). Also, we use Sage [17] to both store the Cayley graph with the given edge colouring and list all colour-preserving automorphisms of that graph (easy to do in Sage [17]).

Algorithm 1 CCA Algorithm

Input: G a group
Output: True if G is CCA, False if it is not

```
MinGens ← AllMinimalGeneratingSets(G) {Algorithm 3}
FoundNonCCA ← False
for all C ∈ MinGens do
    CayGph ← Cay(G,C) with the natural edge colouring
    AutCay ← colour-preserving automorphism group of CayGph
    if |AutCay| ≠ |G| then
        for all φ ∈ AutCay do
            if φ(e) = e and φ ∉ Aut(G) then {Algorithm 2}
                FoundNonCCA ← True.
            end if
        end for
    end if
end for
if FoundNonCCA = True then
    return False
else
    return True
end if
```

We will show the expanded algorithm that checks the condition $\varphi \notin Aut(G)$ which selects one of two "brute force" approaches (whichever is better complexity wise). The first choice looks at each element of $Aut(G)$ and checks to see if that element acts on G the same way φ does. The second choice does a simple homomorphism check on φ, i.e it checks $\varphi(gh) = \varphi(g)\varphi(h)$ for all $g,h \in G$.

Algorithm 2 Checks whether φ is in the automorphism group of the group G.

Input: G a group, $\varphi : G \to G$
Output: True if $\varphi \in Aut(G)$, False otherwise

if $|G| > |Aut(G)|$ **then** {First Choice}
  for all $\psi \in$ *Aut(G)* **do**
    ActsDiff $\leftarrow$ *False*
    for all $g \in G$ **do**
      if $\varphi(g) \neq \psi(g)$ **then**
        ActsDiff $\leftarrow$ *True*
      end if
    end for
    if *ActsDiff* $=$ *False* **then**
      return True
    end if
  end for
  return False
else {Second Choice}
  for all $g, h \in G$ **do**
    if $\varphi(gh) \neq \varphi(g)\varphi(h)$ **then**
      return False
    end if
  end for
  return True
end if

Now, the main algorithm should be fairly clear to understand. The only details which should be expanded on is the *AllMinimalGeneratingSets(G)* algorithm which itself is broken up into a couple of parts. To begin the algorithm, we create a list of elements (*Elements* from Line 2) that we will try to make minimal generating sets from. The list *Elements* will contain exactly one generator for each cyclic subgroup in G. The reason is as follows; suppose $g_1, g_2 \in G$ and $\langle g_1 \rangle = \langle g_2 \rangle$ then if C is a minimal generating set of G with $g_1 \in C$ then we also have that $C \backslash \{g_1\} \cup \{g_2\}$ is a minimal generating set for G. Our strategy will be to find all minimal generating sets containing elements from *Elements*. Then we will use a function *Expand* to take any minimal generating set whose elements are all in the list *Elements*, and find all minimal generating sets that can be formed by replacing some of the generators with other elements that generate the same cyclic subgroup (as we have just described). Lines 3 through 13 create the list *Elements*, and the function *Expand* on Line 17 is a function that takes in a generating set and returns the expanded list using the explanation above.

The *Recurse* function is a recursive algorithm that takes in a set *CurGens* (elements you are using to generate G) and the set *Elements* (elements that you want to consider adding to the previous set to make G, explained above). The algorithm tries every combination of using and not using elements of *Elements* to generate G while also making sure *CurGens* is minimal. This function is expanded on in Algorithm 4.

Finally, we use the function *UniqueUpToAutomorphism* which checks to make sure that a possible addition to our minimal generators is not just a copy of another minimal generating set (with an automorphism applied to it). This is expanded on in Algorithm 5.

We also make a note here that the order in which the elements of G are looked at may change the list *Elements* but we will still get a set of minimal generating sets that is unique up to automorphism.

Algorithm 3 *AllMinimalGeneratingSets*

Input: G a group

Output: A set of all minimal generating sets of G

```
CurGens ← ∅
Elements ← ∅
for all g ∈ G do {Creating list Elements as described above}
    Unique ← True
    for all el ∈ Elements do
        if ⟨el⟩ = ⟨g⟩ then
            Unique ← False
        end if
    end for
    if Unique = True then
        Elements ← Elements ∪ {g}
    end if
end for
MinGensTemp ← Recurse(CurGens, Elements) {Algorithm 4}
MinGens ← ∅
for all Gen ∈ MinGensTemp do
    GenExpanded ← Expand(Gen)
    for all GenSet ∈ GenExpanded do
        if UniqueUpToAutomorphism(GenSet,MinGens) then {Algorithm 5}
            MinGens ← MinGens ∪ {GenSet}
        end if
    end for
end for
return MinGens
```

We now give the details of the recursive algorithm which is the core of finding minimal generating sets. We first give some more detail as to how the algorithm works. First, since this is a recursive algorithm we need base cases. If $\langle \mathit{CurGens} \rangle = G$ that means we have constructed a minimal generating set, so we should return it (Lines 1 through 4). Our second base case is if *Elements* is empty, meaning we have no more elements to try (Line 5). Now, if we have not fallen into one of the base cases, then *CurGens* does not generate G and *Elements* is non-empty. So, we take an element of *Elements* (Line 7) and we can either choose to use it (Lines 8 through 18) or not use it (Line 19, where we recursively try to not use that element). If we do decide to use it, we check to make sure adding it will expand our generated group (Line 8) and we also make sure it does not make any of our other generators redundant (Lines 9 through 14).

Algorithm 4 *Recurse*

Input: *CurGens*, *Elements* sets of elements of G
Output: Partial sets of all minimal generating sets of G

1: $\mathit{GenG} \leftarrow \langle \mathit{CurGens} \rangle$
2: **if** $\mathit{GenG} = G$ **then**
3:     **return** $\{\mathit{CurGens}\}$ {CurGens is a minimal generating set}
4: **end if**
5: **if** $\mathit{Elements} \neq \emptyset$ **then**
6:     $\mathit{RetSets} \leftarrow \emptyset$
7:     $\mathit{Element} \leftarrow$ element of *Elements*
8:     **if** $\mathit{Element} \notin \mathit{GenG}$ **then** {This will try to use *Element*}
9:         $\mathit{MakesOtherElementRedundant} \leftarrow \mathit{False}$
10:         **for all** $c \in \mathit{CurGens}$ **do**
11:             **if** $\langle \mathit{CurGens} \cup \{\mathit{Element}\} \rangle = \langle (\mathit{CurGens} \backslash c) \cup \{\mathit{Element}\} \rangle$ **then**
12:                 $\mathit{MakesOtherElementRedundant} \leftarrow \mathit{True}$
13:             **end if**
14:         **end for**
15:         **if** $\mathit{MakesOtherElementRedundant} = \mathit{False}$ **then**
16:             $\mathit{RetSets} \leftarrow \mathit{RetSets} \cup \mathit{Recurse}(\mathit{CurGens} \cup \{\mathit{Element}\}, \mathit{Elements} \backslash \mathit{Element})$
17:         **end if**
18:     **end if** {Try not using *Element*}
19:     $\mathit{RetSets} \leftarrow \mathit{RetSets} \cup \mathit{Recurse}(\mathit{CurGens}, \mathit{Elements} \backslash \mathit{Element})$
20:     **return** *RetSets*
21: **end if**
22: **return** $\{\}$

Finally we show the short algorithm which checks whether a generating set is unique up to group automorphisms. This algorithm also selects from two algorithms depending on which is better complexity wise. The first choice of the algorithm applies every group automorphism to the minimal generating set that we want to add, and if the transformed set is already in our set of unique (up to group automorphisms) minimal generating sets, then it is not unique so we should not add it. The second choice uses a GAP [8] algorithm that takes in a set C which generates G and a set S (for our purpose, another generating set of G). So $C = \{c_1, ..., c_n\}, S = \{s_1, ..., s_n\} \subseteq G$. The algorithm then quickly checks to see if there is a homomorphism (or in our case, automorphism) φ of G such that $\varphi(c_i) = \varphi(s_i)$ for all i. In this second case we use this function to check *GroupSet* against all permutations of all sets of equal length in *SetofGroupSets*.

Algorithm 5 *UniqueUpToAutomorphism*

Input: *GroupSet* a set of elements of G and *SetofGroupSets* a set of sets of elements of G
Output: True if *GroupSet* is not in *SetofGroupSets* up to automorphism, False otherwise

```
if |Aut(G)| ≤ |GroupSet|! then {Choice 1}
    for all ψ ∈ Aut(G) do
        AutGpSet ← ψ(GroupSet)
        if AutGpSet ∈ SetofGroupSets then
            return False
        end if
    end for
    return True
else {Choice 2}
    for all S ∈ SetofGroupSets such that |S| = |GroupSet| do
        for all S′ a permutation of S do
            if ∃φ from S′ to GroupSet then {Using GAP function}
                return False
            end if
        end for
    end for
    return True
end if
```

Chapter 4

Results

In Chapter 3 we explained the algorithm and program that we wrote to determine which groups (and graphs) are and are not CCA. In this chapter we will analyze the output of the program in Chapter 3. The full table can be found in Appendix B which will show each group up to order 200 (excluding orders 128 and 192) and indicate whether the group was already known to be CCA from past results seen in Chapter 2 or if they are newly found from the program in Chapter 3. We did not run on groups of order 128 and 192 because there are 2328 and 1543 groups of those orders respectively.

4.1 Observations from the Table

Here we list some observations based on the data in the table. These seem to hold true throughout the table but were not checked in every detail. These also may not hold for groups of order over 200.

Orders of the form $4p$ (where p is prime) have only four to five groups (except order 12) and have at most two non-CCA groups. The orders 18, 50, 81, 98 have at most two groups that are non-CCA (they are of the form exactly $p^q q$ where p is a odd prime and q is prime). The five orders 54, 90, 126, 150 and 198 (odd prime multiples of 18, 50, 81, 98) also seem to have mostly CCA groups. The orders that are prime multiples of 21 (42, 63, 105, 147, 189) also tend to have mostly CCA groups (although order 105 only has two unique groups similar to order 21). The orders 36, 56, 84, 88, 104, 108, 136, 140, 152, 184, 196 have close to half CCA groups and half non-CCA groups while orders 60, 90, 126, 132, 156, 162 seem to have more than half of the groups being CCA. The remaining orders seem to have predominantly non-CCA groups.

The first non-CCA group that was not previously known is $S_3 \times S_3$. Using Proposition 2.9 and combining it with these new non-CCA groups give us several new groups that may have not been previously known. In the table, groups with this structure are listed as previously known (as their status can be determined by combining our new knowledge about the original non-CCA group with Proposition 2.9). Similarly new results on CCA groups can be applied with Proposition 2.10. Looking through the tables, the groups that are new mostly seem to be CCA groups. This is because Proposition 2.3 applies to most of the non-CCA groups that were found. However, it is not often easy to see from a group's presentation whether or not it will have the structure described in Proposition 2.3; we used an additional new algorithm (this code is also provided in Appendix A) to determine which of the non-CCA groups have this structure.

4.2 Future Work

In this section we list some ideas for possible future work for the study of the CCA property.

The algorithm used and listed in this work is very much a brute force approach (removing some cases when possible). One possibility could be optimizing this algorithm further to make it run faster on groups to produce more results. One possible way of doing this would be to move some of the automorphism checks into the recursive function instead of doing it all at the end. This would result in cutting off branches of the search tree earlier. This would be beneficial since theoretically the recursive search function has the highest complexity in the algorithm. Another simple change would be to use Lemma 2.23 and only use elements that are prime power orders. This was left out because we wanted our minimal generating set algorithm to be more general and not just to be used for the CCA property.

Another area for future study to improve the algorithm would be coming up with an algorithm to determine all minimal generating sets without using a brute force method. Since the search space can be quite large, this is where the program suffers the most in terms of time. This would significantly increase the number of groups (and graphs) that could be searched.

Several of the results in Chapter 2 rely on the study of non-CCA graphs to determine which groups are non-CCA. Taking the time to study some of the non-CCA graphs (which can be output by the program) may lead to insight on some of the structures of non-CCA graphs.

A project could be to analyze the group structures from the table and make conjectures about general results. This could lead to results giving us a better understanding of which groups are (and are not) CCA.

We make one note on a possible subject for analyzing this table. Searching through the table we noticed several times when we had a group that was a semidirect product involving at least one non-CCA group, it was generally true that the product group was also non-CCA. The first counter-example found in this table was the group $((C_4 \times C_2) : C_4) : C_3$ of order 96 since $(C_4 \times C_2) : C_4$ is non-CCA but the product is CCA. One project could be to study this group and determine why this group is CCA. Another (more difficult) project is to try to generalize the results of Proposition 2.11 to determine exactly when semidirect products result in CCA and non-CCA groups. A first step might be to further study wreath products of groups and determining when those result in CCA and non-CCA groups. Some work on wreath products has appeared in [14].

4.3 Application

In this section we will briefly discuss another application of the all minimal generating sets part of our program. This section will be self contained because it is not the main application that the program was built for.

Definition 4.1. • A **Hamiltonian path** in a graph is a path that meets every vertex (once).

- A **Hamiltonian cycle** in a graph is a cycle that meets every vertex (once).
- A graph is **Hamiltonian connected** if, for every pair of distinct vertices u and v, there is a Hamiltonian path from u to v.
- A bipartite graph is **Hamiltonian laceable** if, for every pair of distinct vertices u and v in opposite halves of the bipartition, there is a Hamiltonian path from u to v.

We note that the last two definitions are a lot stronger than the first two. In [6] the authors (M. Dupuis and S. Wagon) asked a couple of questions pertaining to the Hamiltonian laceable and Hamiltonian connected properties in Hamiltonian, vertex-transitive graphs.

Question 4.2 ([6, Question. 4.1])**.** *Are even cycles the only bipartite, Hamiltonian, vertex-transitive graphs that are not Hamilton laceable?*

Question 4.3 ([6, Question. 4.3])**.** *Are odd cycles and the dodecahedral graph the only nonbipartite, Hamiltonian, vertex-transitive graphs that are not Hamilton connected?*

When a question is asked about vertex-transitive graphs, it is natural to ask similar questions about Cayley graphs. If every Cayley graph on G whose connection set is a minimal generating set is Hamiltonian connected, then every connected Cayley graph on G is Hamiltonian connected (since the same Hamilton path exists). If some Cayley graphs on G whose connection sets are minimal generating sets are Hamiltonian laceable, then additional work must be done to ensure that adding any element to the generating set that creates an odd cycle, results in a Hamiltonian connected graph. Nonetheless, finding all minimal generating sets efficiently is a major piece of this problem.

D. W. Morris (personal communication) used the code that was written to generate all minimal generating sets (and made some modifications for this problem) and combined it with the Lin-Kernighan-Helsgaun Hamiltonian-cycle finder and started looking to see if he could find an example of a connected Cayley graph (which is not just a cycle) that was not Hamiltonian connected or Hamiltonian laceable.

In a fairly short amount of time he was able to confirm that all connected Cayley graphs generated by groups of even order (up to order 100) were either a cycle, Hamiltonian connected or Hamiltonian laceable. He also checked all groups of odd order (up to order 200) and got the same results. These early results suggest that it may be possible that all connected Cayley graphs are either a cycle, Hamiltonian connected or Hamiltonian laceable. This would be an even stronger result than the well known conjecture in Algebraic Graph Theory which states that every connected Cayley graph has a Hamiltonian cycle.

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Appendix A

Code For Chapter 3

In this section we give the core of the code that was used to determine the table in Appendix B. These pieces of code (or updated versions) are available at: https://github.com/brandonfuller621/CCA. The first pieces of code are the GAP [8] functions which determined all minimal generating sets for a particular group.

```
#Returns a list which are the orders of the elements of L.
ListOfOrders := function(L)
  local orders;
  orders := ShallowCopy(L);
  Apply(orders, Order);
  return orders;
end;;

#Checks to see if the current generators (CurrGens) is already a list in
    MinGens by applying an automorphism to it. Returns true if the current
    generators should be added to the
list and returns false otherwise.
#MinGens = current list of minimal generators.
#ElmtsOfAutG = the elements of AutG if CanUseAutG = true, empty set
    otherwise.
#CanUseAutG = a boolean which says true if AutG does not have 'too many
    elements'.
#CurrGens = the current elements that generate G.
#GenG = G.
UniqueUpToAutomorphism := function(MinGens, ElmtsOfAutG, CanUseAutG,
    CurrGens, GenG)
  local i, T, a, g, r, S, perm, permS, CGOrders;

  #If MinGens is empty, we can add CurrGens
  if Length(MG) = 0 then
    return true;
  fi;

  #If checking all permutations of a set (the size of CurrGens) is 'worse'
     than checking all elements of AutG.
  if CanUseAutG = true and Factorial(Length(CurrGens)) > Length(ElmtsOfAutG)
```

```
      then
    for a in ElmtsOfAutG do
      T := [];
      for g in CurrGens do
        Add(T, g^a);
      od;
      Sort(T);
      for i in [1..Length(MinGens)] do
        if MinGens[i] = T then
          return false;
        fi;
      od;
    od;
    return true;
  else #If checking all permutations of a set (the size of CurrGens) is
      'better' than checking all elements of AutG.
    r := Length(CurrGens);
    CGOrders := ListOfOrders(CurrGens);
    for perm in SymmetricGroup(r) do
      for S in MG do
        if Length(S) = r then
          permS := Permuted(S, perm);
          if ListOfOrders(permS) = CGOrders then
            if (GroupHomomorphismByImages(GenG, GenG, permS, CurrGens) <>
                fail) then
              return false;
            fi;
          fi;
        fi;
      od;
    od;
    return true;
  fi;
end;;

#If g is an element the generates the group <g>, then for all k s.t
    gcd(k,|g|) = 1, <g^k> = <g>. In AllMinimalGeneratingSets we remove these
    elements before we use the recurse
function, this refill function undoes that to get all the true minimal
    generating sets using recursion.
#pos = the position of the element of the set mingen that we are considering.
#L = A list. L[i] contains a coprime number to |mg[i]|
#mingen = a minimal generating set.
#MinGen2 = the list which holds all the actual list of all minimal
    generating sets.
#ElmtsOfAutG = the elements of AutG if CanUseAutG = true, empty set
    otherwise.
#CanUseAutG = a boolean which says true if AutG does not have 'too many
```

```
    elements'.
refill := function(pos, L, mingen, MinGens2, ElmtsOfAutG, CanUseAutG)
  local i, mg2, g;
  mg2 := [];
  if pos > Length(mingen) then
    for i in [1..Length(mingen)] do
      Add(mg2, mg[i]^L[i]);
    od;
    if UniqueUpToAutomorphism(MinGen2, ElmtsOfAutG, CanUseAutG, mg2,
        Group(mg2)) then
      Sort(mg2);
      Add(MG2, ShallowCopy(mg2));
    if;
  else
    for i in [1..Order(mg[pos])] do
      if GcdInt(i, Order(mg[pos])) = 1 then
        L[pos] := i;
        refill(pos+1, L, mingen, MinGen2, ElmtsOfAutG, CanUseAutG);
      fi;
    od;
  fi;
end;;

#This is the recursive function that tries all 'reasonable' subsets of Elmts
    to find which ones generate all of Grp.
#Elmts = the elements of G.
#MinGens = the current minimal generating sets.
#CurrGens = the current generators we are testing.
#ElmtsOfAutG = he elements of AutG if CanUseAutG = true, empty set otherwise.
#CanUseAutG = a boolean which says true if AutG does not have 'too many
    elements'.
#pos = the current position of the element we may consider next in Elmts.
#ord = the order of Grp.
recurse := function(Elmts, MinGens, CurrGens, ElmtsOfAutG, CanUseAutG, pos,
    ord)
  local GenG, L, i, B, G1, G2, l;

  #Turn GenG into the group we get with the current generators.
  if Length(CurrGens) = 0 then
    #Make GenG the identity group.
    GenG := Group(E[1]);
  else
    GenG := Group(CurrGens);
  fi;

  #If the order of GenG is the same as the order of G, then CurrGens is a
      minimal generating set. Use UniqueUpToAutomorphism() to check to see
      if it's already in the list via an
```

```
 automorphism of the group. If it is not in the list, then add it.
 if Order(GenG) = ord then
   if UniqueUpToAutomorphism(MinGens, ElmtsOfAutG, CanUseAutG, CurrGens,
       GenG) then
     Add(MG, SortedList(CG));
   fi;
 else #GenG =/= Grp, so we may need to add more to CurrGens.
   #Make sure we are in the bounds of the list Elmts
   if pos < Length(Elmts) + 1 then
     #If Elmts[pos] is not already in GenG, then adding it would make GenG
         larger.
     if not E[pos] in GenG then
       #We now have to make sure that E[pos] does not make any other
           element useless
       B := true;
       L := [];
       for i in [1..Length(CurrGens)] do
         Add(L, CurrGens[i]);
       od;
       Add(L, Elmts[pos]);
       G1 := Group(L);
       for i in [1..Length(L)-1] do
         if B then
           l := Remove(L,i);
           G2 := Group(L);
           Add(L,l,i);
         fi;
         if G1 = G2 then
           B := false;
           break;
         fi;
       od;
       if B then
         #If it did not make another element useless, recursively try using
             Elmts[pos] in CurrGens
         Add(CurrGens, Elmts[pos]);
         recurse(Elmts, MinGens, CurrGens, ElmtsOfAutG, CanUseAutG, pos+1,
             ord);
         Remove(CurrGens);
       fi;
     fi;
     #Recursively try not using Elmts[pos]
     recurse(Elmts, MinGens, CurrGens, ElmtsOfAutG, CanUseAutG, pos+1, ord);
   fi;
 fi;
end;;

#This function takes in a group and returns all minimal generating sets of
```

```
   the group.
#Grp = Group to find all minimal generating sets of.
#LIMIT_AUT_ORDER = The maximum size you allow AutG to be if you want to use
   it.
AllMinimalGeneratingSets := function(Grp, LIMIT_AUT_ORDER)
  local mg, MinGens, MinGen2, CurrGens, pos, AutG, ElmtsOfAutG, CanUseAutG,
     Elmts, Elmts2, i, j, G1, G2, B, L, g;
  Elmts := Enumerator(Grp);
  MinGens := [];
  MinGen2 := [];
  CurrGens := [];
  Elmts2 := [E[1]];
  pos := 2;

  #Filter out the duplicate elements that generate the same subgroup.
  for i in [2..Length(Elmts)] do
    B := true;
    G1 := Group(E[i]);
    for j in [2..Length(Elmts2)] do
      G2 := Group(Elmts2[j]);
      if G1 = G2 then
        B := false;
        break;
      fi;
    od;
    if B = true then
      Add(Elmts2, Elmts[i]);
    fi;
  od;

  #Compare order of AutG with LIMIT_AUT_ORDER and respond accordingly.
  AutG := AutomorphismGroup(G);
  if Order(AutG) > LIMIT_AUT_ORDER then
    CanUseAutG := false;
    ElmtsOfAutG := [];
  else
    CanUseAutG := true;
    ElmtsOfAutG := Enumerator(AutG);
  fi;

  recurse(Elmts2, MinGens, CurrGens, ElmtsOfAutG, CanUseAutG, pos,
     Order(Grp));

  #Fill in the minimal generators by creating all the ones you lost when you
     filtered out some of the elements of Grp.
  for mg in MinGens do
    L := [];
    pos := 1;
```

```
    for g in mg do
      Add(L, 0);
    od;
    refill(pos, L, mg, MinGen2, ElmtsOfAutG, CanUseAutG);
  od;
  return MinGen2;
end;;
```

The next piece of code is the Sage [17] function which determined whether or not a group was CCA. It relies on the GAP functions above.

```
#Returns true if the group is CCA and false if it is not CCA.
#Grp = The group you are checking for the CCA property.
#LIMIT_AUT_ORDER = The maximum size you allow AutG to be if you want to use
    it.
 def DetermineIfCCA(Grp, LIMIT_AUT_ORDER):
    AutG = gap.AutomorphismGroup(Grp);
    MinGens = gap.AllMinimalGeneratingSets(Grp, LIMIT_AUT_ORDER);

    nonCCA = False
    for GenSet in MinGens:
        if nonCCA:
            break

        #Create Cayley graph with natural edge colours
        CayGph = Graph()
        Elmts = gap.Enumerator(Grp);
        CayGph.add_vertices(Elmts)
        for i in range(1, gap.Length(GenSet) + 1):
            for g in Elmts:
                CayGph.add_edge(g, g*GenSet[i], str(i))

        #Get all colour preserving automorphisms of the Cayley Graph
        CayGphAutG = CayGph.automorphism_group(edge_labels = True)

        if gap(CayGphAutG.order()) == gap.Order(Grp):
            return true;

        B1 = True

        #If checking that each automorphism of the Cayley Graph (that fix
            the identity) is 'better' than checking if it acts the same as an
            automorphism in AutG.
        if gap.Order(Grp) <= gap.Order(AutG):
            for l in CayGphAutG:
                #See if l fixes the identity
                if l(Elmts[1]) == Elmts[1]:
                    #Check if l preserves the operation of the group (and if
```

```
                        so, it is an automorphism of the group)
                    for g1 in Elmts:
                        for g2 in Elmts:
                            if l(g1*g2) != l(g1)*l(g2):
                                B1 = False
                                break
                        if B1 == False:
                            break
                    if B1 == False:
                        break
        else: #If checking that each automorphism of the Cayley Graph (that
            fix the identity) is 'worse' than checking if it acts the same as
            an automorphism in AutG.
            ElmtsOfAutG = gap.Enumerator(AutG)
            for l in CayGphAutG:
                #See if l fixes the identity
                if l(Elmts[1]) == Elmts[1]:
                    B2 = False
                    for a in ElmtsOfAutG:
                        B3 = True
                        for e in Elmts:
                            if e^a != l(e):
                                B3 = False
                                break
                        if B3 == True:
                            B2 = True
                            break
                    if B2 == False:
                        B1 = False
                        break

        #A nonaffine automorphism was found
        if B1 == False:
            nonCCA = True

    if nonCCA == True:
        return False
    else:
        return True
```

The next four functions were used as helper functions written in GAP [8] to determine which groups were abelian, a generalized dihedral group, a generalized dicyclic group or if it follows the structure of Proposition 2.3.

```
#Determines if the inputed group Grp is abelian.
IsAbelian := function(Grp)
  local i, j, Elmts;
  Elmts := Enumerator(Grp);
```

```
  for i in [1..Length(Elmts)] do
    for j in [1..Length(Elmts)] do
      if not (Elmts[i]*Elmts[j] = Elmts[j]*Elmts[i]) then
        return false;
      fi;
    od;
  od;
  return true;

#Determines if the inputed group Grp is a generalized dihedral group.
IsGenDih := function(Grp)
  local G1, G2, B, Elmts, Elmts2, e, e2;
  Elmts := Enumerator(Grp);
  G1 := MaximalSubgroups(G);
  for G2 in G1 do
    if Order(Grp) = Order(G2)*2 then
      B := IsAbelian(G2);
      if B = true then
        Elmts2 := Enumerator(G2);
        for e in Elmts do
          if not (e in G2) then
            B := true;
            for e2 in Elmts2 do
              if not (e*e2*e*e2 = Elmts[1]) then
                B := false;
                break;
              fi;
            od;
            if B = true then
              return true;
            fi;
          fi;
        od;
      fi;
    fi;
  od;
  return false;
end;;

#Determines if the inputed group Grp is a generalized dicyclic group.
IsGenDic := function(Grp)
  local G1, G2, B, Elmts, Elmts2, e, e2;
  Elmts := Enumerator(Grp);
  G1 := MaximalSubgroups(Grp);
  for G2 in G1 do
    if Order(Grp) = Order(G2)*2 then
      Elmts2 := Enumerator(G2);
      B := IsAbelian(G2);
```

```
      if B = true then
        for e in Elmts do
          if not (e in G2) then
            if Order(e) = 4 then
              if e*e in G2 then
                for e2 in Elmts2 do
                  if not (e*e*e*e2*e*e2 = Elmts[1]) then
                    B := false;
                  fi;
                od;
                if B = true then
                  return true;
                fi;
              fi;
            fi;
          fi;
        od;
      fi;
    fi;
  od;
  return false;
end;;

#Determines if the inputed group Grp follows the Structure of Prop 2.3
PropStruc := function(Grp, LIMIT_AUT_ORDER)
  local G1, Elmts, e, C, C2, c, MinGens, tau, T1, T2, B, l, l2, Center;
  Elmts := Enumerator(Grp);
  MinGens := AllMinimalGeneratingSets(Grp, LIMIT_AUT_ORDER);
  for C in MinGens do
    for tau in E do
      if Order(tau) = 2 then

        #Checks if tau*c*tau = c or c^-1
        B := true;
        for c in C do
          if not (tau*c*tau = c or tau*c*tau*c = Elmts[1]) then
            B := false;
            break;
          fi;
        od;

        if B = true then

          #Checks if tau is in the center of Grp
          Center := true;
          for e in Elmts do
            if not (tau*e = e*tau) then
              Center := false;
```

```
          break;
        fi;
      od;

      #Put the elements that could be in T into T1
      T1 := [];
      for c in C do
        if c*c = tau then
          Add(T1,c);
        fi;
      od;

      #Try all subsets of T1 for the possible T (put into T2)
      for T2 in Combinations(T1) do

        #Turn C2 into (C\T2) union {tau}
        C2 := [];
        for c in C do
          if not (c in T2) then
            Add(C2, c);
          fi;
        od;
        Add(C2, tau);

        #See if This C, T and tau satisfy the remaining two properties
        G1 := Group(C2);
        if not (G1 = Grp) then
          if Order(G1)*2 < Order(Grp) or not Center then
            return true;
          fi;
        fi;
      od;
    fi;
  fi;
 od;
od;

#If no C, T, tau satifies the properties, return false.
return false;
end;;
```

We note that it can be verified that using minimal generating sets for C is sufficient when checking for Proposition 2.3 in a group.

Appendix B

Table of Results

We now show the table that contains all the results produced by the program in determining whether or not groups have the CCA property. We will only consider looking at groups with orders that are at least 8 and have a divisor of the form 4, 21 or $p^q q$ (where p is odd and p, q are primes) because Corollary 2.24 tells us that all other groups are CCA. We did test our program on groups of other orders. The program agreed with Corollary 2.24 that every other group up to order 100 was CCA.

In our table, the first column is the order of the group. The second column is the GAP ID of the group. The third column is the structure of the group. The fourth column says if the group is CCA or non-CCA. The fifth column is whether the group was already known from a result in Chapter 2. Again, in all cases, the results of the algorithm agreed with any theoretical results. Since a group can fall under several different results, we made a priority on which results we would list in the table. Some of the non-CCA groups may succumb to 2.11 even if this is not indicated here.

The . denotes a non-split extension. Several of these groups have alternative forms that are equivalent in GAP [8] but we have removed the alternate forms. Groups that had their alternate forms removed have a $*$ next to them.

Four groups ran for a longer time than others (up to a week) without returning CCA or Non-CCA. In these cases we checked by hand that these groups succumb to theoretical results (and their status was not confirmed by the program). These groups have a $\sim$ (along with whether or not that group is CCA) in the 'CCA Property' column of the table. The four groups checked by hand were:

- $C_2 \times C_2 \times C_2 \times C_2 \times D_{10}$ (Order $n = 160$ with GAP ID $k = 237$) which falls under Proposition 2.15.
- $C_2 \times C_{14} \times S_3$ (Order $n = 168$ with GAP ID $k = 55$) which falls under Proposition 2.10.
- $C_{10} \times D_{18}$ (Order $n = 180$ with GAP ID $k = 10$) which falls under Proposition 2.10.
- $C_{15} \times A_4$ (Order $n = 180$ with GAP ID $k = 31$) which falls under Proposition 2.10.

Below the first table is another table. This second table indicates how many unique (up to automorphism) minimal generating sets there are for each group.

Order	GAP ID	Group Structure	CCA Prop.	Known
$n = 8$	$k = 1$	C_8	CCA	Prop. 2.12
	$k = 2$	$C_4 \times C_2$	Non-CCA	Ex. 2.2
	$k = 3$	D_8	CCA	Cor. 2.16
	$k = 4$	Q_8	Non-CCA	Ex. 2.2
	$k = 5$	$C_2 \times C_2 \times C_2$	CCA	Prop. 2.12
$n = 12$	$k = 1$	$C_3 : C_4$	Non-CCA	Cor. 2.4
	$k = 2$	C_{12}	CCA	Prop. 2.12
	$k = 3$	A_4	CCA	Prop. 2.27
	$k = 4$	D_{12}	CCA	Cor. 2.16
	$k = 5$	$C_6 \times C_2$	CCA	Prop. 2.12
$n = 16$	$k = 1$	C_{16}	CCA	Prop. 2.12
	$k = 2$	$C_4 \times C_4$	CCA	Prop. 2.12
	$k = 3$	$(C_4 \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 4$	$C_4 : C_4$	Non-CCA	Cor. 2.4
	$k = 5$	$C_8 \times C_2$	CCA	Prop. 2.12
	$k = 6$	$C_8 : C_2$	CCA	Prop. 2.27
	$k = 7$	D_{16}	CCA	Cor. 2.16
	$k = 8$	QD_{16}	Non-CCA	Cor. 2.4
	$k = 9$	Q_{16}	Non-CCA	Cor. 2.4
	$k = 10$	$C_4 \times C_2 \times C_2$	Non-CCA	Prop. 2.12
	$k = 11$	$C_2 \times D_8$	Non-CCA	Prop. 2.15
	$k = 12$	$C_2 \times Q_8$	Non-CCA	Prop. 2.9
	$k = 13$	$(C_4 \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 14$	$C_2 \times C_2 \times C_2 \times C_2$	CCA	Prop. 2.12
$n = 18$	$k = 1$	D_{18}	CCA	Cor. 2.16
	$k = 2$	C_{18}	CCA	Prop. 2.12
	$k = 3$	$C_3 \times S_3$	Non-CCA	Prop. 2.26
	$k = 4$	$(C_3 \times C_3) : C_2$	CCA	Prop. 2.15
	$k = 5$	$C_6 \times C_3$	CCA	Prop. 2.12
$n = 20$	$k = 1$	$C_5 : C_4$	Non-CCA	Cor. 2.4
	$k = 2$	C_{20}	CCA	Prop. 2.12
	$k = 3$	$C_5 : C_4$	Non-CCA	Prop. 2.3
	$k = 4$	D_{20}	CCA	Cor. 2.16
	$k = 5$	$C_{10} \times C_2$	CCA	Prop. 2.12
$n = 21$	$k = 1$	$C_7 : C_3$	Non-CCA	Ex. 2.6
	$k = 2$	C_{21}	CCA	Prop. 2.12
$n = 24$	$k = 1$	$C_3 : C_8$	CCA	Prop. 2.27
	$k = 2$	C_{24}	CCA	Prop. 2.12

$n = 24$	$k = 3$	$SL(2,3)$	Non-CCA	Prop. 2.3
	$k = 4$	$C_3 : Q_8$	Non-CCA	Cor. 2.4
	$k = 5$	$C_4 \times S_3$	Non-CCA	Prop. 2.3
	$k = 6$	D_{24}	CCA	Cor. 2.16
	$k = 7$	$C_2 \times (C_3 : C_4)$	Non-CCA	Prop. 2.9
	$k = 8$	$(C_6 \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 9$	$C_{12} \times C_2$	Non-CCA	Prop. 2.12
	$k = 10$	$C_3 \times D_8$	CCA	Prop. 2.10
	$k = 11$	$C_3 \times Q_8$	Non-CCA	Prop. 2.9
	$k = 12$	S_4	Non-CCA	Prop. 2.3
	$k = 13$	$C_2 \times A_4$	CCA	Prop. 2.27
	$k = 14$	$C_2 \times C_2 \times S_3$	CCA	Prop. 2.15
	$k = 15$	$C_6 \times C_2 \times C_2$	CCA	Prop. 2.12
$n = 28$	$k = 1$	$C_7 : C_4$	Non-CCA	Cor. 2.4
	$k = 2$	C_{28}	CCA	Prop. 2.12
	$k = 3$	D_{28}	CCA	Cor. 2.16
	$k = 4$	$C_{14} \times C_2$	CCA	Prop. 2.12
$n = 32$	$k = 1$	C_{32}	CCA	Prop. 2.12
	$k = 2$	$(C_4 \times C_2) : C_4$	Non-CCA	Prop. 2.3
	$k = 3$	$C_8 \times C_4$	CCA	Prop. 2.12
	$k = 4$	$C_8 : C_4$	CCA	
	$k = 5$	$(C_8 \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 6$	$((C_4 \times C_2) : C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 7$	$(C_8 : C_2) : C_2$	CCA	
	$k = 8$	$(C_2 \times C_2).(C_4 \times C_2)*$	Non-CCA	Prop. 2.3
	$k = 9$	$(C_8 \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 10$	$Q_8 : C_4$	Non-CCA	Prop. 2.3
	$k = 11$	$(C_4 \times C_4) : C_2$	Non-CCA	Prop. 2.15
	$k = 12$	$C_4 : C_8$	CCA	
	$k = 13$	$C_8 : C_4$	Non-CCA	Prop. 2.3
	$k = 14$	$C_8 : C_4$	Non-CCA	Cor. 2.4
	$k = 15$	$C_4.D_8*$	CCA	
	$k = 16$	$C_{16} \times C_2$	CCA	Prop. 2.12
	$k = 17$	$C_{16} : C_2$	CCA	
	$k = 18$	D_{32}	CCA	Cor. 2.16
	$k = 19$	QD_{32}	Non-CCA	Cor. 2.4
	$k = 20$	Q_{32}	Non-CCA	Cor. 2.4
	$k = 21$	$C_4 \times C_4 \times C_2$	Non-CCA	Prop. 2.12
	$k = 22$	$C_2 \times ((C_4 \times C_2) : C_2)$	Non-CCA	Prop. 2.9

$n=32$	$k=23$	$C_2 \times (C_4 : C_4)$	Non-CCA	Prop. 2.9
	$k=24$	$(C_4 \times C_4) : C_2$	Non-CCA	Prop. 2.3
	$k=25$	$C_4 \times D_8$	Non-CCA	Prop. 2.3
	$k=26$	$C_4 \times Q_8$	Non-CCA	Prop. 2.9
	$k=27$	$(C_2 \times C_2 \times C_2 \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k=28$	$(C_4 \times C_2 \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k=29$	$(C_2 \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k=30$	$(C_4 \times C_2 \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k=31$	$(C_4 \times C_4) : C_2$	Non-CCA	Prop. 2.3
	$k=32$	$(C_2 \times C_2).(C_2 \times C_2 \times C_2)$	Non-CCA	Prop. 2.3
	$k=33$	$(C_4 \times C_4) : C_2$	Non-CCA	Prop. 2.3
	$k=34$	$(C_4 \times C_4) : C_2$	CCA	
	$k=35$	$C_4 : Q_8$	Non-CCA	Cor. 2.4
	$k=36$	$C_8 \times C_2 \times C_2$	Non-CCA	Prop. 2.12
	$k=37$	$C_2 \times (C_8 : C_2)$	Non-CCA	Prop. 2.3
	$k=38$	$(C_8 \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k=39$	$C_2 \times D_{16}$	CCA	Prop. 2.15
	$k=40$	$C_2 \times QD_{16}$	Non-CCA	Prop. 2.9
	$k=41$	$C_2 \times Q_{16}$	Non-CCA	Prop. 2.9
	$k=42$	$(C_8 \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k=43$	$(C_2 \times D_8) : C_2$	Non-CCA	Prop. 2.3
	$k=44$	$(C_2 \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k=45$	$C_4 \times C_2 \times C_2 \times C_2$	Non-CCA	Prop. 2.12
	$k=46$	$C_2 \times C_2 \times D_8$	Non-CCA	Prop. 2.15
	$k=47$	$C_2 \times C_2 \times Q_8$	Non-CCA	Prop. 2.9
	$k=48$	$C_2 \times ((C_4 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k=49$	$(C_2 \times D_8) : C_2$	Non-CCA	Prop. 2.3
	$k=50$	$(C_2 \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k=51$	$C_2 \times C_2 \times C_2 \times C_2 \times C_2$	CCA	Prop. 2.12
$n=36$	$k=1$	$C_9 : C_4$	Non-CCA	Cor. 2.4
	$k=2$	C_{36}	CCA	Prop. 2.12
	$k=3$	$(C_2 \times C_2) : C_9$	CCA	
	$k=4$	D_{36}	CCA	Cor. 2.16
	$k=5$	$C_{18} \times C_2$	CCA	Prop. 2.12
	$k=6$	$C_3 \times (C_3 : C_4)$	Non-CCA	Prop. 2.9
	$k=7$	$(C_3 \times C_3) : C_4$	Non-CCA	Cor. 2.4
	$k=8$	$C_{12} \times C_3$	CCA	Prop. 2.12
	$k=9$	$(C_3 \times C_3) : C_4$	Non-CCA	Prop. 2.3
	$k=10$	$S_3 \times S_3$	Non-CCA	

$n=36$	$k=11$	$C_3 \times A_4$	CCA	
	$k=12$	$C_6 \times S_3$	Non-CCA	Prop. 2.9
	$k=13$	$C_2 \times ((C_3 \times C_3) : C_2)$	CCA	Prop. 2.15
	$k=14$	$C_6 \times C_6$	CCA	Prop. 2.12
$n=40$	$k=1$	$C_5 : C_8$	CCA	
	$k=2$	C_{40}	CCA	Prop. 2.12
	$k=3$	$C_5 : C_8$	Non-CCA	Prop. 2.3
	$k=4$	$C_5 : Q_8$	Non-CCA	Cor. 2.4
	$k=5$	$C_4 \times D_{10}$	Non-CCA	Prop. 2.3
	$k=6$	D_{40}	CCA	Cor. 2.16
	$k=7$	$C_2 \times (C_5 : C_4)$	Non-CCA	Prop. 2.9
	$k=8$	$(C_{10} \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k=9$	$C_{20} \times C_2$	Non-CCA	Prop. 2.12
	$k=10$	$C_5 \times D_8$	CCA	Prop. 2.10
	$k=11$	$C_5 \times Q_8$	Non-CCA	Prop. 2.9
	$k=12$	$C_2 \times (C_5 : C_4)$	Non-CCA	Prop. 2.9
	$k=13$	$C_2 \times C_2 \times D_{10}$	CCA	Prop. 2.15
	$k=14$	$C_{10} \times C_2 \times C_2$	CCA	Prop. 2.12
$n=42$	$k=1$	$(C_7 : C_3) : C_2$	Non-CCA	
	$k=2$	$C_2 \times (C_7 : C_3)$	Non-CCA	Prop. 2.9
	$k=3$	$C_7 \times S_3$	CCA	Prop. 2.10
	$k=4$	$C_3 \times D_{14}$	CCA	Prop. 2.10
	$k=5$	D_{42}	CCA	Cor. 2.16
	$k=6$	C_{42}	CCA	Prop. 2.12
$n=44$	$k=1$	$C_{11} : C_4$	Non-CCA	Cor. 2.4
	$k=2$	C_{44}	CCA	Prop. 2.12
	$k=3$	D_{44}	CCA	Cor. 2.16
	$k=4$	$C_{22} \times C_2$	CCA	Prop. 2.12
$n=48$	$k=1$	$C_3 : C_{16}$	CCA	
	$k=2$	C_{48}	CCA	Prop. 2.12
	$k=3$	$(C_4 \times C_4) : C_3$	CCA	
	$k=4$	$C_8 \times S_3$	Non-CCA	Prop. 2.3
	$k=5$	$C_{24} : C_2$	Non-CCA	Prop. 2.3
	$k=6$	$C_{24} : C_2$	Non-CCA	Prop. 2.3
	$k=7$	D_{48}	CCA	Cor. 2.16
	$k=8$	$C_3 : Q_{16}$	Non-CCA	Cor. 2.4
	$k=9$	$C_2 \times (C_3 : C_8)$	CCA	
	$k=10$	$(C_3 : C_8) : C_2$	CCA	
	$k=11$	$C_4 \times (C_3 : C_4)$	Non-CCA	Prop. 2.9

$n=48$	$k=12$	$(C_3:C_4):C_4$	Non-CCA	Prop. 2.3
	$k=13$	$C_{12}:C_4$	Non-CCA	Cor. 2.4
	$k=14$	$(C_{12}\times C_2):C_2$	Non-CCA	Prop. 2.3
	$k=15$	$(C_3\times D_8):C_2$	CCA	
	$k=16$	$(C_3:C_8):C_2$	Non-CCA	Prop. 2.3
	$k=17$	$(C_3\times Q_8):C_2$	Non-CCA	Prop. 2.3
	$k=18$	$C_3:Q_{16}$	Non-CCA	Prop. 2.3
	$k=19$	$(C_2\times(C_3:C_4)):C_2$	Non-CCA	Prop. 2.3
	$k=20$	$C_{12}\times C_4$	CCA	Prop. 2.12
	$k=21$	$C_3\times((C_4\times C_2):C_2)$	Non-CCA	Prop. 2.9
	$k=22$	$C_3\times(C_4:C_4)$	Non-CCA	Prop. 2.9
	$k=23$	$C_{24}\times C_2$	CCA	Prop. 2.12
	$k=24$	$C_3\times(C_8:C_2)$	CCA	Prop. 2.10
	$k=25$	$C_3\times D_{16}$	CCA	Prop. 2.10
	$k=26$	$C_3\times QD_{16}$	Non-CCA	Prop. 2.9
	$k=27$	$C_3\times Q_{16}$	Non-CCA	Prop. 2.9
	$k=28$	$C_2.S_4*$	Non-CCA	Prop. 2.3
	$k=29$	$GL(2,3)$	Non-CCA	Prop. 2.3
	$k=30$	$A_4:C_4$	Non-CCA	Prop. 2.3
	$k=31$	$C_4\times A_4$	Non-CCA	Prop. 2.3
	$k=32$	$C_2\times SL(2,3)$	Non-CCA	Prop. 2.9
	$k=33$	$SL(2,3):C_2$	Non-CCA	Prop. 2.3
	$k=34$	$C_2\times(C_3:Q_8)$	Non-CCA	Prop. 2.9
	$k=35$	$C_2\times C_4\times S_3$	Non-CCA	Prop. 2.9
	$k=36$	$C_2\times D_{24}$	Non-CCA	Prop. 2.15
	$k=37$	$(C_{12}\times C_2):C_2$	Non-CCA	Prop. 2.3
	$k=38$	$D_8\times S_3$	Non-CCA	Prop. 2.3
	$k=39$	$(C_2\times(C_3:C_4)):C_2$	Non-CCA	Prop. 2.3
	$k=40$	$Q_8\times S_3$	Non-CCA	Prop. 2.9
	$k=41$	$(C_4\times S_3):C_2$	Non-CCA	Prop. 2.3
	$k=42$	$C_2\times C_2\times(C_3:C_4)$	Non-CCA	Prop. 2.9
	$k=43$	$C_2\times((C_6\times C_2):C_2)$	Non-CCA	Prop. 2.9
	$k=44$	$C_{12}\times C_2\times C_2$	Non-CCA	Prop. 2.12
	$k=45$	$C_6\times D_8$	Non-CCA	Prop. 2.9
	$k=46$	$C_6\times Q_8$	Non-CCA	Prop. 2.9
	$k=47$	$C_3\times((C_4\times C_2):C_2)$	Non-CCA	Prop. 2.9
	$k=48$	$C_2\times S_4$	Non-CCA	Prop. 2.9
	$k=49$	$C_2\times C_2\times A_4$	CCA	
	$k=50$	$(C_2\times C_2\times C_2\times C_2):C_3$	CCA	

$n=48$	$k=51$	$C_2 \times C_2 \times C_2 \times S_3$	CCA	Prop. 2.15
	$k=52$	$C_6 \times C_2 \times C_2 \times C_2$	CCA	Prop. 2.12
$n=50$	$k=1$	D_{50}	CCA	Cor. 2.16
	$k=2$	C_{50}	CCA	Prop. 2.12
	$k=3$	$C_5 \times D_{10}$	Non-CCA	
	$k=4$	$(C_5 \times C_5) : C_2$	CCA	Prop. 2.15
	$k=5$	$C_{10} \times C_5$	CCA	Prop. 2.12
$n=52$	$k=1$	$C_{13} : C_4$	Non-CCA	Cor. 2.4
	$k=2$	C_{52}	CCA	Prop. 2.12
	$k=3$	$C_{13} : C_4$	Non-CCA	Prop. 2.3
	$k=4$	D_{52}	CCA	Cor. 2.16
	$k=5$	$C_{26} \times C_2$	CCA	Prop. 2.12
$n=54$	$k=1$	D_{54}	CCA	Cor. 2.16
	$k=2$	C_{54}	CCA	Prop. 2.12
	$k=3$	$C_3 \times D_{18}$	CCA	
	$k=4$	$C_9 \times S_3$	CCA	
	$k=5$	$((C_3 \times C_3) : C_3) : C_2$	Non-CCA	
	$k=6$	$(C_9 : C_3) : C_2$	CCA	
	$k=7$	$(C_9 \times C_3) : C_2$	CCA	Prop. 2.15
	$k=8$	$((C_3 \times C_3) : C_3) : C_2$	CCA	
	$k=9$	$C_{18} \times C_3$	CCA	Prop. 2.12
	$k=10$	$C_2 \times ((C_3 \times C_3) : C_3)$	CCA	Prop. 2.10
	$k=11$	$C_2 \times (C_9 : C_3)$	CCA	Prop. 2.10
	$k=12$	$C_3 \times C_3 \times S_3$	Non-CCA	Prop. 2.9
	$k=13$	$C_3 \times ((C_3 \times C_3) : C_2)$	Non-CCA	
	$k=14$	$(C_3 \times C_3 \times C_3) : C_2$	CCA	Prop. 2.15
	$k=15$	$C_6 \times C_3 \times C_3$	CCA	Prop. 2.12
$n=56$	$k=1$	$C_7 : C_8$	CCA	
	$k=2$	C_{56}	CCA	Prop. 2.12
	$k=3$	$C_7 : Q_8$	Non-CCA	Cor. 2.4
	$k=4$	$C_4 \times D_{14}$	Non-CCA	Prop. 2.3
	$k=5$	D_{56}	CCA	Cor. 2.16
	$k=6$	$C_2 \times (C_7 : C_4)$	Non-CCA	Prop. 2.9
	$k=7$	$(C_{14} \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k=8$	$C_{28} \times C_2$	Non-CCA	Prop. 2.12
	$k=9$	$C_7 \times D_8$	CCA	Prop. 2.10
	$k=10$	$C_7 \times Q_8$	Non-CCA	Prop. 2.9
	$k=11$	$(C_2 \times C_2 \times C_2) : C_7$	CCA	
	$k=12$	$C_2 \times C_2 \times D_{14}$	CCA	Prop. 2.15

$n = 56$	$k = 13$	$C_{14} \times C_2 \times C_2$	CCA	Prop. 2.12
$n = 60$	$k = 1$	$C_5 \times (C_3 : C_4)$	Non-CCA	Prop. 2.9
	$k = 2$	$C_3 \times (C_5 : C_4)$	Non-CCA	Prop. 2.9
	$k = 3$	$C_{15} : C_4$	Non-CCA	Cor. 2.4
	$k = 4$	C_{60}	CCA	Prop. 2.12
	$k = 5$	A_5	CCA	
	$k = 6$	$C_3 \times (C_5 : C_4)$	Non-CCA	Prop. 2.9
	$k = 7$	$C_{15} : C_4$	Non-CCA	Prop. 2.3
	$k = 8$	$S_3 \times D_{10}$	CCA	
	$k = 9$	$C_5 \times A_4$	CCA	Prop. 2.10
	$k = 10$	$C_6 \times D_{10}$	CCA	Prop. 2.10
	$k = 11$	$C_{10} \times S_3$	CCA	Prop. 2.10
	$k = 12$	D_{60}	CCA	Cor. 2.16
	$k = 13$	$C_{30} \times C_2$	CCA	Prop. 2.12
$n = 63$	$k = 1$	$C_7 : C_9$	CCA	
	$k = 2$	C_{63}	CCA	Prop. 2.12
	$k = 3$	$C_3 \times (C_7 : C_3)$	Non-CCA	Prop. 2.9
	$k = 4$	$C_{21} \times C_3$	CCA	Prop. 2.12
$n = 64$	$k = 1$	C_{64}	CCA	Prop. 2.12
	$k = 2$	$C_8 \times C_8$	CCA	Prop. 2.12
	$k = 3$	$C_8 : C_8$	CCA	
	$k = 4$	$((C_8 \times C_2) : C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 5$	$(C_4 \times C_2) : C_8$	Non-CCA	Prop. 2.3
	$k = 6$	$(C_8 \times C_4) : C_2$	Non-CCA	Prop. 2.15
	$k = 7$	$Q_8 : C_8$	Non-CCA	Prop. 2.3
	$k = 8$	$((C_8 \times C_2) : C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 9$	$(C_2 \times Q_8) : C_4$	Non-CCA	Prop. 2.3
	$k = 10$	$(C_8 : C_4) : C_2$	Non-CCA	Prop. 2.3
	$k = 11$	$(C_4 \times C_2).(C_4 \times C_2)*$	Non-CCA	Prop. 2.3
	$k = 12$	$(C_4 : C_8) : C_2$	CCA	
	$k = 13$	$(C_4 \times C_2).(C_4 \times C_2)*$	Non-CCA	Prop. 2.3
	$k = 14$	$(C_4 \times C_2).(C_4 \times C_2)*$	Non-CCA	Prop. 2.3
	$k = 15$	$C_8 : C_8$	CCA	
	$k = 16$	$C_8 : C_8$	CCA	
	$k = 17$	$(C_8 \times C_2) : C_4$	Non-CCA	Prop. 2.3
	$k = 18$	$(C_8 \times C_2) : C_4$	Non-CCA	
	$k = 19$	$C_4.(C_4 \times C_4)$	CCA	
	$k = 20$	$(C_4 \times C_4) : C_4$	Non-CCA	Prop. 2.3
	$k = 21$	$(C_8 \times C_2) : C_4$	Non-CCA	Prop. 2.3

	$k=22$	$C_4.(C_4 \times C_4)*$	CCA	
	$k=23$	$(C_4 \times C_2 \times C_2):C_4$	Non-CCA	Prop. 2.3
	$k=24$	$(C_8:C_2):C_4$	Non-CCA	Prop. 2.3
	$k=25$	$(C_8 \times C_2):C_4$	Non-CCA	
	$k=26$	$C_{16} \times C_4$	CCA	Prop. 2.12
	$k=27$	$C_{16}:C_4$	CCA	
	$k=28$	$C_{16}:C_4$	CCA	
	$k=29$	$(C_{16} \times C_2):C_2$	Non-CCA	Prop. 2.3
	$k=30$	$(C_{16}:C_2):C_2$	Non-CCA	Prop. 2.3
	$k=31$	$(C_{16} \times C_2):C_2$	Non-CCA	Prop. 2.3
	$k=32$	$((C_8:C_2):C_2):C_2$	Non-CCA	Prop. 2.3
	$k=33$	$(C_4 \times C_2 \times C_2):C_4$	Non-CCA	Prop. 2.3
	$k=34$	$(((C_4 \times C_2):C_2):C_2):C_2$	Non-CCA	Prop. 2.3
	$k=35$	$(C_4 \times C_4):C_4$	Non-CCA	Prop. 2.3
	$k=36$	$((C_2 \times C_2).(C_4 \times C_2)):C_2*$	Non-CCA	
	$k=37$	$(C_4 \times C_2).(C_4 \times C_2)*$	Non-CCA	Prop. 2.3
	$k=38$	$(C_{16} \times C_2):C_2$	Non-CCA	Prop. 2.3
	$k=39$	$Q_{16}:C_4$	Non-CCA	Prop. 2.3
	$k=40$	$(C_{16} \times C_2):C_2$	Non-CCA	Prop. 2.3
$n=64$	$k=41$	$(C_{16}:C_2):C_2$	Non-CCA	Prop. 2.3
	$k=42$	$(C_{16}:C_2):C_2$	CCA	
	$k=43$	$C_8.(C_4 \times C_2)*$	Non-CCA	Prop. 2.3
	$k=44$	$C_4:C_{16}$	CCA	
	$k=45$	$C_8.D_8*$	CCA	
	$k=46$	$C_{16}:C_4$	Non-CCA	
	$k=47$	$C_{16}:C_4$	Non-CCA	Cor. 2.4
	$k=48$	$C_{16}:C_4$	Non-CCA	Prop. 2.3
	$k=49$	$C_4.D_{16}*$	CCA	
	$k=50$	$C_{32} \times C_2$	CCA	Prop. 2.12
	$k=51$	$C_{32}:C_2$	CCA	
	$k=52$	D_{64}	CCA	Cor. 2.16
	$k=53$	QD_{64}	Non-CCA	Cor. 2.4
	$k=54$	Q_{64}	Non-CCA	Cor. 2.4
	$k=55$	$C_4 \times C_4 \times C_4$	CCA	Prop. 2.12
	$k=56$	$C_2 \times ((C_4 \times C_2):C_4)$	Non-CCA	Prop. 2.9
	$k=57$	$(C_4 \times C_4):C_4$	Non-CCA	
	$k=58$	$C_4 \times ((C_4 \times C_2):C_2)$	Non-CCA	Prop. 2.9
	$k=59$	$C_4 \times (C_4:C_4)$	Non-CCA	Prop. 2.9
	$k=60$	$(C_2 \times ((C_4 \times C_2):C_2)):C_2$	Non-CCA	Prop. 2.3

	$k = 61$	$(C_2 \times (C_4 : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k = 62$	$((C_4 \times C_2) : C_4) : C_2$	Non-CCA	Prop. 2.3
	$k = 63$	$(C_4 \times C_4) : C_4$	Non-CCA	Prop. 2.3
	$k = 64$	$(C_4 \times C_4) : C_4$	Non-CCA	
	$k = 65$	$(C_4 \times C_4) : C_4$	Non-CCA	Cor. 2.4
	$k = 66$	$(C_2 \times (C_4 : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k = 67$	$(C_4 \times C_2 \times C_2 \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 68$	$(C_4 : C_4) : C_4$	Non-CCA	Prop. 2.3
	$k = 69$	$(C_4 \times C_4 \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 70$	$(C_4 : C_4) : C_4$	Non-CCA	Prop. 2.3
	$k = 71$	$(C_4 \times C_4 \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 72$	$(C_2 \times Q_8) : C_4$	Non-CCA	Prop. 2.3
	$k = 73$	$(C_2 \times C_2 \times D_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 74$	$(C_2 \times C_2 \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 75$	$(C_2 \times ((C_4 \times C_2) : C_2)) : C_2$	Non-CCA	Prop. 2.3
	$k = 76$	$(C_4 \times C_2) : Q_8$	Non-CCA	Prop. 2.3
	$k = 77$	$(C_2 \times (C_4 : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k = 78$	$(C_2 \times (C_4 : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k = 79$	$(C_2 \times C_2 \times C_2).(C_2 \times C_2 \times C_2)$	Non-CCA	Prop. 2.3
$n = 64$	$k = 80$	$(C_2 \times (C_4 : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k = 81$	$(C_2 \times C_2 \times C_2).(C_2 \times C_2 \times C_2)$	Non-CCA	Prop. 2.3
	$k = 82$	$(C_2 \times C_2 \times C_2).(C_2 \times C_2 \times C_2)$	Non-CCA	
	$k = 83$	$C_8 \times C_4 \times C_2$	Non-CCA	Prop. 2.12
	$k = 84$	$C_2 \times (C_8 : C_4)$	Non-CCA	Prop. 2.3
	$k = 85$	$C_4 \times (C_8 : C_2)$	Non-CCA	Prop. 2.3
	$k = 86$	$(C_8 \times C_4) : C_2$	Non-CCA	Prop. 2.3
	$k = 87$	$C_2 \times ((C_8 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 88$	$(C_2 \times (C_8 : C_2)) : C_2$	Non-CCA	Prop. 2.3
	$k = 89$	$(C_8 \times C_2 \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 90$	$C_2 \times (((C_4 \times C_2) : C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 91$	$(((C_4 \times C_2) : C_2) : C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 92$	$C_2 \times ((C_8 : C_2) : C_2)$	CCA	
	$k = 93$	$C_2 \times ((C_2 \times C_2).(C_4 \times C_2))*$	Non-CCA	Prop. 2.9
	$k = 94$	$(C_2 \times (C_8 : C_2)) : C_2$	Non-CCA	Prop. 2.3
	$k = 95$	$C_2 \times ((C_8 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 96$	$C_2 \times (Q_8 : C_4)$	Non-CCA	Prop. 2.3
	$k = 97$	$(C_8 \times C_2 \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 98$	$(C_2 \times (C_8 : C_2)) : C_2$	Non-CCA	Prop. 2.3
	$k = 99$	$(C_2 \times (C_8 : C_2)) : C_2$	Non-CCA	Prop. 2.3

$n = 64$	$k = 100$	$(Q_8 : C_4) : C_2$	Non-CCA	Prop. 2.3
	$k = 101$	$C_2 \times ((C_4 \times C_4) : C_2)$	Non-CCA	Prop. 2.3
	$k = 102$	$(C_2 \times (C_8 : C_2)) : C_2$	Non-CCA	Prop. 2.3
	$k = 103$	$C_2 \times (C_4 : C_8)$	Non-CCA	Prop. 2.3
	$k = 104$	$(C_4 : C_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 105$	$(C_4 : C_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 106$	$C_2 \times (C_8 : C_4)$	Non-CCA	Prop. 2.3
	$k = 107$	$C_2 \times (C_8 : C_4)$	Non-CCA	Cor. 2.4
	$k = 108$	$(C_8 : C_4) : C_2$	Non-CCA	Prop. 2.3
	$k = 109$	$(C_8 : C_4) : C_2$	Non-CCA	Prop. 2.3
	$k = 110$	$C_2 \times (C_4.D_8)*$	CCA	
	$k = 111$	$(C_4.D_8) : C_2*$	CCA	
	$k = 112$	$(C_8 \times C_4) : C_2$	Non-CCA	Prop. 2.3
	$k = 113$	$(C_4 : C_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 114$	$(C_8 \times C_4) : C_2$	Non-CCA	Prop. 2.3
	$k = 115$	$C_8 \times D_8$	Non-CCA	Prop. 2.3
	$k = 116$	$(C_8 \times C_2 \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 117$	$(C_8 \times C_4) : C_2$	Non-CCA	Prop. 2.3
	$k = 118$	$C_4 \times D_{16}$	Non-CCA	Prop. 2.3
	$k = 119$	$C_4 \times QD_{16}$	Non-CCA	Prop. 2.9
	$k = 120$	$C_4 \times Q_{16}$	Non-CCA	Prop. 2.9
	$k = 121$	$(C_4 \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 122$	$Q_{16} : C_4$	Non-CCA	Prop. 2.3
	$k = 123$	$(C_4 \times D_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 124$	$(C_8 \times C_4) : C_2$	Non-CCA	Prop. 2.3
	$k = 125$	$((C_4 \times C_4) : C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 126$	$C_8 \times Q_8$	Non-CCA	Prop. 2.9
	$k = 127$	$C_8 : Q_8$	Non-CCA	Prop. 2.3
	$k = 128$	$(C_2 \times C_2 \times D_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 129$	$(C_2 \times C_2 \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 130$	$(C_2 \times D_{16}) : C_2$	Non-CCA	Prop. 2.3
	$k = 131$	$(C_2 \times QD_{16}) : C_2$	Non-CCA	Prop. 2.3
	$k = 132$	$(C_2 \times Q_{16}) : C_2$	Non-CCA	Prop. 2.3
	$k = 133$	$(C_2 \times Q_{16}) : C_2$	Non-CCA	Prop. 2.3
	$k = 134$	$((C_4 \times C_4) : C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 135$	$((C_4 \times C_4) : C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 136$	$((C_4 \times C_4) : C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 137$	$((C_4 \times C_4) : C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 138$	$(((C_4 \times C_2) : C_2) : C_2) : C_2$	Non-CCA	Prop. 2.3

	$k=139$	$(((C_4 \times C_2):C_2):C_2):C_2$	Non-CCA	Prop. 2.3
	$k=140$	$(C_4 \times D_8):C_2$	Non-CCA	Prop. 2.3
	$k=141$	$(C_2 \times QD_{16}):C_2$	Non-CCA	Prop. 2.3
	$k=142$	$(Q_8:C_4):C_2$	Non-CCA	Prop. 2.3
	$k=143$	$C_4:Q_{16}$	Non-CCA	Prop. 2.3
	$k=144$	$(C_4 \times D_8):C_2$	Non-CCA	Prop. 2.3
	$k=145$	$(C_2 \times Q_{16}):C_2$	Non-CCA	Prop. 2.3
	$k=146$	$(C_8 \times C_2 \times C_2):C_2$	Non-CCA	Prop. 2.3
	$k=147$	$(C_8 \times C_2 \times C_2):C_2$	Non-CCA	Prop. 2.3
	$k=148$	$(C_2 \times Q_{16}):C_2$	Non-CCA	Prop. 2.3
	$k=149$	$(C_2 \times (C_8:C_2)):C_2$	Non-CCA	Prop. 2.3
	$k=150$	$(C_2 \times (C_8:C_2)):C_2$	Non-CCA	Prop. 2.3
	$k=151$	$(C_2 \times Q_{16}):C_2$	Non-CCA	Prop. 2.3
	$k=152$	$(C_2 \times QD_{16}):C_2$	Non-CCA	Prop. 2.3
	$k=153$	$(C_2 \times D_{16}):C_2$	Non-CCA	Prop. 2.3
	$k=154$	$(C_2 \times Q_{16}):C_2$	Non-CCA	Prop. 2.3
	$k=155$	$(C_8:C_4):C_2$	Non-CCA	Prop. 2.3
	$k=156$	$Q_8:Q_8$	Non-CCA	Prop. 2.3
	$k=157$	$(C_8:C_4):C_2$	Non-CCA	Prop. 2.3
$n=64$	$k=158$	$Q_8:Q_8$	Non-CCA	Prop. 2.3
	$k=159$	$(C_8:C_4):C_2$	Non-CCA	Prop. 2.3
	$k=160$	$(C_2 \times C_2).(C_2 \times D_8)*$	Non-CCA	Prop. 2.3
	$k=161$	$(C_2 \times (C_4:C_4)):C_2$	Non-CCA	Prop. 2.3
	$k=162$	$(C_2 \times (C_4:C_4)):C_2$	Non-CCA	Prop. 2.3
	$k=163$	$((C_8 \times C_2):C_2):C_2$	Non-CCA	Prop. 2.3
	$k=164$	$(Q_8:C_4):C_2$	Non-CCA	Prop. 2.3
	$k=165$	$(Q_8:C_4):C_2$	Non-CCA	Prop. 2.3
	$k=166$	$(C_8:C_4):C_2$	Non-CCA	Prop. 2.3
	$k=167$	$(C_8 \times C_4):C_2$	Non-CCA	Prop. 2.3
	$k=168$	$(C_2 \times C_2).(C_2 \times D_8)*$	Non-CCA	Prop. 2.3
	$k=169$	$(C_8 \times C_4):C_2$	Non-CCA	Prop. 2.3
	$k=170$	$(Q_8:C_4):C_2$	Non-CCA	Prop. 2.3
	$k=171$	$((C_8 \times C_2):C_2):C_2$	Non-CCA	Prop. 2.3
	$k=172$	$(C_2 \times C_2).(C_2 \times D_8)*$	Non-CCA	Prop. 2.3
	$k=173$	$(C_8 \times C_4):C_2$	Non-CCA	Prop. 2.3
	$k=174$	$(C_8 \times C_4):C_2$	CCA	
	$k=175$	$C_4:Q_{16}$	Non-CCA	Cor. 2.4
	$k=176$	$(C_8 \times C_4):C_2$	Non-CCA	Prop. 2.3
	$k=177$	$(C_2 \times D_{16}):C_2$	Non-CCA	Prop. 2.3

$n = 64$	$k = 178$	$(C_2 \times Q_{16}) : C_2$	Non-CCA	Prop. 2.3
	$k = 179$	$C_8 : Q_8$	Non-CCA	Prop. 2.3
	$k = 180$	$(C_2 \times C_2).(C_2 \times D_8)*$	Non-CCA	Prop. 2.3
	$k = 181$	$C_8 : Q_8$	Non-CCA	Cor. 2.4
	$k = 182$	$C_8 : Q_8$	Non-CCA	Prop. 2.3
	$k = 183$	$C_{16} \times C_2 \times C_2$	Non-CCA	Prop. 2.12
	$k = 184$	$C_2 \times (C_{16} : C_2)$	Non-CCA	Prop. 2.3
	$k = 185$	$(C_{16} \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 186$	$C_2 \times D_{32}$	CCA	Prop. 2.15
	$k = 187$	$C_2 \times QD_{32}$	Non-CCA	Prop. 2.9
	$k = 188$	$C_2 \times Q_{32}$	Non-CCA	Prop. 2.9
	$k = 189$	$(C_{16} \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 190$	$(C_2 \times D_{16}) : C_2$	Non-CCA	Prop. 2.3
	$k = 191$	$(C_2 \times Q_{16}) : C_2$	Non-CCA	Prop. 2.3
	$k = 192$	$C_4 \times C_4 \times C_2 \times C_2$	Non-CCA	Prop. 2.12
	$k = 193$	$C_2 \times C_2 \times ((C_4 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 194$	$C_2 \times C_2 \times (C_4 : C_4)$	Non-CCA	Prop. 2.9
	$k = 195$	$C_2 \times ((C_4 \times C_4) : C_2)$	Non-CCA	Prop. 2.15
	$k = 196$	$C_2 \times C_4 \times D_8$	Non-CCA	Prop. 2.9
	$k = 197$	$C_2 \times C_4 \times Q_8$	Non-CCA	Prop. 2.9
	$k = 198$	$C_4 \times ((C_4 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 199$	$(C_4 \times D_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 200$	$(C_4 \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 201$	$(C_4 \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 202$	$C_2 \times ((C_2 \times C_2 \times C_2 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 203$	$C_2 \times ((C_4 \times C_2 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 204$	$C_2 \times ((C_2 \times Q_8) : C_2)$	Non-CCA	Prop. 2.9
	$k = 205$	$C_2 \times ((C_4 \times C_2 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 206$	$(C_4 \times C_2 \times C_2 \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 207$	$C_2 \times ((C_4 \times C_4) : C_2)$	Non-CCA	Prop. 2.3
	$k = 208$	$C_2 \times ((C_2 \times C_2).(C_2 \times C_2 \times C_2))$	Non-CCA	Prop. 2.9
	$k = 209$	$C_2 \times ((C_4 \times C_4) : C_2)$	Non-CCA	Prop. 2.3
	$k = 210$	$(C_4 \times C_4 \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 211$	$C_2 \times ((C_4 \times C_4) : C_2)$	Non-CCA	Prop. 2.3
	$k = 212$	$C_2 \times (C_4 : Q_8)$	Non-CCA	Prop. 2.9
	$k = 213$	$(C_4 \times C_4 \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 214$	$(C_4 \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 215$	$(C_2 \times C_2 \times D_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 216$	$(C_2 \times C_2 \times D_8) : C_2$	Non-CCA	Prop. 2.3

$n = 64$	$k = 217$	$(C_2 \times C_2 \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 218$	$(C_2 \times ((C_4 \times C_2) : C_2)) : C_2$	Non-CCA	Prop. 2.3
	$k = 219$	$(C_4 \times D_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 220$	$(C_4 \times D_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 221$	$(C_4 \times D_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 222$	$(C_4 \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 223$	$(C_4 \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 224$	$((C_2 \times Q_8) : C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 225$	$(C_4 : Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 226$	$D_8 \times D_8$	Non-CCA	Prop. 2.3
	$k = 227$	$(C_2 \times C_2 \times D_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 228$	$(C_4 \times D_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 229$	$(C_2 \times C_2 \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 230$	$Q_8 \times D_8$	Non-CCA	Prop. 2.9
	$k = 231$	$(C_4 \times D_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 232$	$(C_4 \times D_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 233$	$(C_4 \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 234$	$(C_4 \times D_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 235$	$(C_4 \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 236$	$(C_4 \times D_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 237$	$(C_4 \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 238$	$Q_8 : Q_8$	Non-CCA	Prop. 2.3
	$k = 239$	$Q_8 \times Q_8$	Non-CCA	Prop. 2.9
	$k = 240$	$(C_4 \times D_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 241$	$((C_4 \times C_2 \times C_2) : C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 242$	$((C_4 \times C_4) : C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 243$	$((C_2 \times C_2).(C_2 \times C_2 \times C_2)) : C_2$	Non-CCA	Prop. 2.3
	$k = 244$	$((C_4 \times C_4) : C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 245$	$(C_2 \times C_2).(C_2 \times C_2 \times C_2 \times C_2)$	Non-CCA	Prop. 2.3
	$k = 246$	$C_8 \times C_2 \times C_2 \times C_2$	Non-CCA	Prop. 2.12
	$k = 247$	$C_2 \times C_2 \times (C_8 : C_2)$	Non-CCA	Prop. 2.3
	$k = 248$	$C_2 \times ((C_8 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 249$	$(C_2 \times (C_8 : C_2)) : C_2$	Non-CCA	Prop. 2.3
	$k = 250$	$C_2 \times C_2 \times D_{16}$	Non-CCA	Prop. 2.15
	$k = 251$	$C_2 \times C_2 \times QD_{16}$	Non-CCA	Prop. 2.9
	$k = 252$	$C_2 \times C_2 \times Q_{16}$	Non-CCA	Prop. 2.9
	$k = 253$	$C_2 \times ((C_8 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 254$	$C_2 \times ((C_2 \times D_8) : C_2)$	Non-CCA	Prop. 2.9
	$k = 255$	$C_2 \times ((C_2 \times Q_8) : C_2)$	Non-CCA	Prop. 2.9

$n=64$	$k=256$	$(C_2\times(C_8:C_2)):C_2$	Non-CCA	Prop. 2.3
	$k=257$	$(C_2\times D_{16}):C_2$	Non-CCA	Prop. 2.3
	$k=258$	$(C_2\times QD_{16}):C_2$	Non-CCA	Prop. 2.3
	$k=259$	$(C_2\times Q_{16}):C_2$	Non-CCA	Prop. 2.3
	$k=260$	$C_4\times C_2\times C_2\times C_2\times C_2$	Non-CCA	Prop. 2.12
	$k=261$	$C_2\times C_2\times C_2\times D_8$	Non-CCA	Prop. 2.15
	$k=262$	$C_2\times C_2\times C_2\times Q_8$	Non-CCA	Prop. 2.9
	$k=263$	$C_2\times C_2\times((C_4\times C_2):C_2)$	Non-CCA	Prop. 2.9
	$k=264$	$C_2\times((C_2\times D_8):C_2)$	Non-CCA	Prop. 2.9
	$k=265$	$C_2\times((C_2\times Q_8):C_2)$	Non-CCA	Prop. 2.9
	$k=266$	$(C_2\times((C_4\times C_2):C_2)):C_2$	Non-CCA	Prop. 2.3
	$k=267$	$C_2\times C_2\times C_2\times C_2\times C_2\times C_2$	CCA	Prop. 2.12
$n=68$	$k=1$	$C_{17}:C_4$	Non-CCA	Cor. 2.4
	$k=2$	C_{68}	CCA	Prop. 2.12
	$k=3$	$C_{17}:C_4$	Non-CCA	Prop. 2.3
	$k=4$	D_{68}	CCA	Cor. 2.16
	$k=5$	$C_{34}\times C_2$	CCA	Prop. 2.12
$n=72$	$k=1$	$C_9:C_8$	CCA	
	$k=2$	C_{72}	CCA	Prop. 2.12
	$k=3$	$Q_8:C_9$	Non-CCA	Prop. 2.3
	$k=4$	$C_9:Q_8$	Non-CCA	Cor. 2.4
	$k=5$	$C_4\times D_{18}$	Non-CCA	Prop. 2.3
	$k=6$	D_{72}	CCA	Cor. 2.16
	$k=7$	$C_2\times(C_9:C_4)$	Non-CCA	Prop. 2.9
	$k=8$	$(C_{18}\times C_2):C_2$	Non-CCA	Prop. 2.3
	$k=9$	$C_{36}\times C_2$	Non-CCA	Prop. 2.12
	$k=10$	$C_9\times D_8$	CCA	Prop. 2.10
	$k=11$	$C_9\times Q_8$	Non-CCA	Prop. 2.9
	$k=12$	$C_3\times(C_3:C_8)$	Non-CCA	
	$k=13$	$(C_3\times C_3):C_8$	CCA	
	$k=14$	$C_{24}\times C_3$	CCA	Prop. 2.12
	$k=15$	$((C_2\times C_2):C_9):C_2$	Non-CCA	Prop. 2.3
	$k=16$	$C_2\times((C_2\times C_2):C_9)$	CCA	
	$k=17$	$C_2\times C_2\times D_{18}$	CCA	Prop. 2.15
	$k=18$	$C_{18}\times C_2\times C_2$	CCA	Prop. 2.12
	$k=19$	$(C_3\times C_3):C_8$	Non-CCA	Prop. 2.3
	$k=20$	$(C_3:C_4)\times S_3$	Non-CCA	Prop. 2.9
	$k=21$	$(C_3\times(C_3:C_4)):C_2$	Non-CCA	Prop. 2.3
	$k=22$	$(C_6\times S_3):C_2$	Non-CCA	Prop. 2.3

$n = 72$	$k = 23$	$(C_6 \times S_3) : C_2$	Non-CCA	Prop. 2.3
	$k = 24$	$(C_3 \times C_3) : Q_8$	Non-CCA	Prop. 2.3
	$k = 25$	$C_3 \times SL(2,3)$	Non-CCA	Prop. 2.9
	$k = 26$	$C_3 \times (C_3 : Q_8)$	Non-CCA	Prop. 2.9
	$k = 27$	$C_{12} \times S_3$	Non-CCA	Prop. 2.3
	$k = 28$	$C_3 \times D_{24}$	Non-CCA	
	$k = 29$	$C_6 \times (C_3 : C_4)$	Non-CCA	Prop. 2.9
	$k = 30$	$C_3 \times ((C_6 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 31$	$(C_3 \times C_3) : Q_8$	Non-CCA	Cor. 2.4
	$k = 32$	$C_4 \times ((C_3 \times C_3) : C_2)$	Non-CCA	
	$k = 33$	$(C_{12} \times C_3) : C_2$	CCA	Prop. 2.15
	$k = 34$	$C_2 \times ((C_3 \times C_3) : C_4)$	Non-CCA	Prop. 2.9
	$k = 35$	$(C_6 \times C_6) : C_2$	Non-CCA	Prop. 2.3
	$k = 36$	$C_{12} \times C_6$	Non-CCA	Prop. 2.12
	$k = 37$	$C_3 \times C_3 \times D_8$	CCA	Prop. 2.10
	$k = 38$	$C_3 \times C_3 \times Q_8$	Non-CCA	Prop. 2.9
	$k = 39$	$(C_3 \times C_3) : C_8$	Non-CCA	
	$k = 40$	$(S_3 \times S_3) : C_2$	Non-CCA	Prop. 2.3
	$k = 41$	$(C_3 \times C_3) : Q_8$	Non-CCA	Prop. 2.3
	$k = 42$	$C_3 \times S_4$	Non-CCA	Prop. 2.9
	$k = 43$	$(C_3 \times A_4) : C_2$	Non-CCA	Prop. 2.3
	$k = 44$	$A_4 \times S_3$	CCA	
	$k = 45$	$C_2 \times ((C_3 \times C_3) : C_4)$	Non-CCA	Prop. 2.9
	$k = 46$	$C_2 \times S_3 \times S_3$	Non-CCA	Prop. 2.9
	$k = 47$	$C_6 \times A_4$	CCA	
	$k = 48$	$C_2 \times C_6 \times S_3$	Non-CCA	Prop. 2.9
	$k = 49$	$C_2 \times C_2 \times ((C_3 \times C_3) : C_2)$	CCA	Prop. 2.15
	$k = 50$	$C_6 \times C_6 \times C_2$	CCA	Prop. 2.12
$n = 76$	$k = 1$	$C_{19} : C_4$	Non-CCA	Cor. 2.4
	$k = 2$	C_{76}	CCA	Prop. 2.12
	$k = 3$	D_{76}	CCA	Cor. 2.16
	$k = 4$	$C_{38} \times C_2$	CCA	Prop. 2.12
$n = 80$	$k = 1$	$C_5 : C_{16}$	CCA	
	$k = 2$	C_{80}	CCA	Prop. 2.12
	$k = 3$	$C_5 : C_{16}$	Non-CCA	
	$k = 4$	$C_8 \times D_{10}$	Non-CCA	Prop. 2.3
	$k = 5$	$C_{40} : C_2$	Non-CCA	Prop. 2.3
	$k = 6$	$C_{40} : C_2$	Non-CCA	Prop. 2.3
	$k = 7$	D_{80}	CCA	Cor. 2.16

	$k=8$	$C_5 : Q_{16}$	Non-CCA	Cor. 2.4
	$k=9$	$C_2 \times (C_5 : C_8)$	CCA	
	$k=10$	$(C_5 : C_8) : C_2$	CCA	
	$k=11$	$C_4 \times (C_5 : C_4)$	Non-CCA	Prop. 2.9
	$k=12$	$(C_5 : C_4) : C_4$	Non-CCA	Prop. 2.3
	$k=13$	$C_{20} : C_4$	Non-CCA	Cor. 2.4
	$k=14$	$(C_{20} \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k=15$	$(C_5 \times D_8) : C_2$	CCA	
	$k=16$	$(C_5 : C_8) : C_2$	Non-CCA	Prop. 2.3
	$k=17$	$(C_5 \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k=18$	$C_5 : Q_{16}$	Non-CCA	Prop. 2.3
	$k=19$	$(C_2 \times (C_5 : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k=20$	$C_{20} \times C_4$	CCA	Prop. 2.12
	$k=21$	$C_5 \times ((C_4 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k=22$	$C_5 \times (C_4 : C_4)$	Non-CCA	Prop. 2.9
	$k=23$	$C_{40} \times C_2$	CCA	Prop. 2.12
	$k=24$	$C_5 \times (C_8 : C_2)$	CCA	Prop. 2.10
	$k=25$	$C_5 \times D_{16}$	CCA	Prop. 2.10
	$k=26$	$C_5 \times QD_{16}$	Non-CCA	Prop. 2.9
$n=80$	$k=27$	$C_5 \times Q_{16}$	Non-CCA	Prop. 2.9
	$k=28$	$(C_5 : C_8) : C_2$	Non-CCA	Prop. 2.3
	$k=29$	$(C_5 : C_8) : C_2$	Non-CCA	Prop. 2.3
	$k=30$	$C_4 \times (C_5 : C_4)$	Non-CCA	Prop. 2.9
	$k=31$	$C_{20} : C_4$	Non-CCA	Prop. 2.3
	$k=32$	$C_2 \times (C_5 : C_8)$	Non-CCA	Prop. 2.9
	$k=33$	$(C_5 : C_8) : C_2$	Non-CCA	Prop. 2.3
	$k=34$	$(C_2 \times (C_5 : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k=35$	$C_2 \times (C_5 : Q_8)$	Non-CCA	Prop. 2.9
	$k=36$	$C_2 \times C_4 \times D_{10}$	Non-CCA	Prop. 2.9
	$k=37$	$C_2 \times D_{40}$	Non-CCA	Prop. 2.15
	$k=38$	$(C_{20} \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k=39$	$D_8 \times D_{10}$	Non-CCA	Prop. 2.3
	$k=40$	$(C_2 \times (C_5 : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k=41$	$Q_8 \times D_{10}$	Non-CCA	Prop. 2.9
	$k=42$	$(C_4 \times D_{10}) : C_2$	Non-CCA	Prop. 2.3
	$k=43$	$C_2 \times C_2 \times (C_5 : C_4)$	Non-CCA	Prop. 2.9
	$k=44$	$C_2 \times ((C_{10} \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k=45$	$C_{20} \times C_2 \times C_2$	Non-CCA	Prop. 2.12
	$k=46$	$C_{10} \times D_8$	Non-CCA	Prop. 2.9

$n=80$	$k=47$	$C_{10}\times Q_8$	Non-CCA	Prop. 2.9
	$k=48$	$C_5\times((C_4\times C_2):C_2)$	Non-CCA	Prop. 2.9
	$k=49$	$(C_2\times C_2\times C_2\times C_2):C_5$	CCA	
	$k=50$	$C_2\times C_2\times(C_5:C_4)$	Non-CCA	Prop. 2.9
	$k=51$	$C_2\times C_2\times C_2\times D_{10}$	CCA	Prop. 2.15
	$k=52$	$C_{10}\times C_2\times C_2\times C_2$	CCA	Prop. 2.12
$n=81$	$k=1$	C_{81}	CCA	Prop. 2.12
	$k=2$	$C_9\times C_9$	CCA	Prop. 2.12
	$k=3$	$(C_9\times C_3):C_3$	CCA	
	$k=4$	$C_9:C_9$	CCA	
	$k=5$	$C_{27}\times C_3$	CCA	Prop. 2.12
	$k=6$	$C_{27}:C_3$	CCA	
	$k=7$	$(C_3\times C_3\times C_3):C_3$	Non-CCA	
	$k=8$	$(C_9\times C_3):C_3$	CCA	
	$k=9$	$(C_9\times C_3):C_3$	CCA	
	$k=10$	$(C_3\times C_3).(C_3\times C_3)*$	CCA	
	$k=11$	$C_9\times C_3\times C_3$	CCA	Prop. 2.12
	$k=12$	$C_3\times((C_3\times C_3):C_3)$	CCA	
	$k=13$	$C_3\times(C_9:C_3)$	CCA	
	$k=14$	$(C_9\times C_3):C_3$	CCA	
	$k=15$	$C_3\times C_3\times C_3\times C_3$	CCA	Prop. 2.12
$n=84$	$k=1$	$(C_7:C_4):C_3$	Non-CCA	Prop. 2.3
	$k=2$	$C_4\times(C_7:C_3)$	Non-CCA	Prop. 2.9
	$k=3$	$C_7\times(C_3:C_4)$	Non-CCA	Prop. 2.9
	$k=4$	$C_3\times(C_7:C_4)$	Non-CCA	Prop. 2.9
	$k=5$	$C_{21}:C_4$	Non-CCA	Cor. 2.4
	$k=6$	C_{84}	CCA	Prop. 2.12
	$k=7$	$C_2\times((C_7:C_3):C_2)$	Non-CCA	Prop. 2.9
	$k=8$	$S_3\times D_{14}$	CCA	
	$k=9$	$C_2\times C_2\times(C_7:C_3)$	Non-CCA	Prop. 2.9
	$k=10$	$C_7\times A_4$	CCA	Prop. 2.10
	$k=11$	$(C_{14}\times C_2):C_3$	CCA	
	$k=12$	$C_6\times D_{14}$	CCA	Prop. 2.10
	$k=13$	$C_{14}\times S_3$	CCA	Prop. 2.10
	$k=14$	D_{84}	CCA	Cor. 2.16
	$k=15$	$C_{42}\times C_2$	CCA	Prop. 2.12
$n=88$	$k=1$	$C_{11}:C_8$	CCA	
	$k=2$	C_{88}	CCA	Prop. 2.12
	$k=3$	$C_{11}:Q_8$	Non-CCA	Cor. 2.4

$n=88$	$k=4$	$C_4 \times D_{22}$	Non-CCA	Prop. 2.3
	$k=5$	D_{88}	CCA	Cor. 2.16
	$k=6$	$C_2 \times (C_{11} : C_4)$	Non-CCA	Prop. 2.9
	$k=7$	$(C_{22} \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k=8$	$C_{44} \times C_2$	Non-CCA	Prop. 2.12
	$k=9$	$C_{11} \times D_8$	CCA	Prop. 2.10
	$k=10$	$C_{11} \times Q_8$	Non-CCA	Prop. 2.9
	$k=11$	$C_2 \times C_2 \times D_{22}$	CCA	Prop. 2.15
	$k=12$	$C_{22} \times C_2 \times C_2$	CCA	Prop. 2.12
$n=90$	$k=1$	$C_5 \times D_{18}$	CCA	Prop. 2.10
	$k=2$	$C_9 \times D_{10}$	CCA	Prop. 2.10
	$k=3$	D_{90}	CCA	Cor. 2.16
	$k=4$	C_{90}	CCA	Prop. 2.12
	$k=5$	$C_3 \times C_3 \times D_{10}$	CCA	Prop. 2.10
	$k=6$	$C_{15} \times S_3$	Non-CCA	
	$k=7$	$C_3 \times D_{30}$	Non-CCA	
	$k=8$	$C_5 \times ((C_3 \times C_3) : C_2)$	CCA	Prop. 2.10
	$k=9$	$(C_{15} \times C_3) : C_2$	CCA	Prop. 2.15
	$k=10$	$C_{30} \times C_3$	CCA	Prop. 2.12
$n=92$	$k=1$	$C_{23} : C_4$	Non-CCA	Cor. 2.4
	$k=2$	C_{92}	CCA	Prop. 2.12
	$k=3$	D_{92}	CCA	Cor. 2.16
	$k=4$	$C_{46} \times C_2$	CCA	Prop. 2.12
$n=96$	$k=1$	$C_3 : C_{32}$	CCA	
	$k=2$	C_{96}	CCA	Prop. 2.12
	$k=3$	$((C_4 \times C_2) : C_4) : C_3$	CCA	
	$k=4$	$C_{16} \times S_3$	Non-CCA	Prop. 2.3
	$k=5$	$C_{48} : C_2$	Non-CCA	Prop. 2.3
	$k=6$	D_{96}	CCA	Cor. 2.16
	$k=7$	$C_{48} : C_2$	Non-CCA	Prop. 2.3
	$k=8$	$C_3 : Q_{32}$	Non-CCA	Cor. 2.4
	$k=9$	$C_4 \times (C_3 : C_8)$	CCA	
	$k=10$	$(C_3 : C_8) : C_4$	CCA	
	$k=11$	$C_{12} : C_8$	CCA	
	$k=12$	$(C_{12} \times C_4) : C_2$	Non-CCA	Prop. 2.15
	$k=13$	$(C_3 \times ((C_4 \times C_2) : C_2)) : C_2$	Non-CCA	
	$k=14$	$(C_3 : C_8) : C_4$	Non-CCA	Prop. 2.3
	$k=15$	$(C_3 : C_8) : C_4$	Non-CCA	Prop. 2.3
	$k=16$	$(C_2 \times (C_3 : C_8)) : C_2$	Non-CCA	Prop. 2.3

	$k=17$	$(C_3:Q_8):C_4$	Non-CCA	Prop. 2.3
	$k=18$	$C_2\times(C_3:C_{16})$	CCA	
	$k=19$	$(C_3:C_{16}):C_2$	CCA	
	$k=20$	$C_8\times(C_3:C_4)$	Non-CCA	Prop. 2.9
	$k=21$	$(C_3:C_4):C_8$	Non-CCA	Prop. 2.3
	$k=22$	$C_{24}:C_4$	Non-CCA	Prop. 2.3
	$k=23$	$(C_3:Q_8):C_4$	Non-CCA	Prop. 2.3
	$k=24$	$C_{24}:C_4$	Non-CCA	Prop. 2.3
	$k=25$	$C_{24}:C_4$	Non-CCA	Cor. 2.4
	$k=26$	$C_3:(C_4.D_8)*$	CCA	Prop. 2.3
	$k=27$	$(C_{24}\times C_2):C_2$	Non-CCA	Prop. 2.3
	$k=28$	$(C_{24}\times C_2):C_2$	Non-CCA	Prop. 2.3
	$k=29$	$C_3:(C_4.D_8)*$	CCA	
	$k=30$	$(C_3\times(C_8:C_2)):C_2$	CCA	
	$k=31$	$C_3:((C_2\times C_2).(C_4\times C_2))*$	Non-CCA	Prop. 2.3
	$k=32$	$(C_3\times(C_8:C_2)):C_2$	Non-CCA	Prop. 2.3
	$k=33$	$(C_3\times D_{16}):C_2$	CCA	
	$k=34$	$(C_3:C_{16}):C_2$	Non-CCA	Prop. 2.3
	$k=35$	$(C_3\times Q_{16}):C_2$	Non-CCA	Prop. 2.3
$n=96$	$k=36$	$C_3:Q_{32}$	Non-CCA	Prop. 2.3
	$k=37$	$(C_2\times(C_3:C_8)):C_2$	Non-CCA	Prop. 2.3
	$k=38$	$(C_{12}\times C_2):C_4$	Non-CCA	Prop. 2.3
	$k=39$	$(C_2\times(C_3:C_8)):C_2$	Non-CCA	Prop. 2.3
	$k=40$	$((C_3:C_8):C_2):C_2$	CCA	
	$k=41$	$((C_2\times(C_3:C_4)):C_2):C_2$	Non-CCA	Prop. 2.3
	$k=42$	$(C_3\times Q_8):C_4$	Non-CCA	Prop. 2.3
	$k=43$	$C_3:((C_2\times C_2).(C_4\times C_2))*$	Non-CCA	Prop. 2.3
	$k=44$	$(C_4\times(C_3:C_4)):C_2$	Non-CCA	Prop. 2.3
	$k=45$	$C_3\times((C_4\times C_2):C_4)$	Non-CCA	Prop. 2.9
	$k=46$	$C_{24}\times C_4$	CCA	Prop. 2.12
	$k=47$	$C_3\times(C_8:C_4)$	CCA	Prop. 2.10
	$k=48$	$C_3\times((C_8\times C_2):C_2)$	Non-CCA	Prop. 2.9
	$k=49$	$C_3\times(((C_4\times C_2):C_2):C_2)$	Non-CCA	Prop. 2.9
	$k=50$	$C_3\times((C_8:C_2):C_2)$	CCA	Prop. 2.10
	$k=51$	$C_3\times((C_2\times C_2).(C_4\times C_2))*$	Non-CCA	Prop. 2.9
	$k=52$	$C_3\times((C_8\times C_2):C_2)$	Non-CCA	Prop. 2.9
	$k=53$	$C_3\times(Q_8:C_4)$	Non-CCA	Prop. 2.9
	$k=54$	$C_3\times((C_4\times C_4):C_2)$	Non-CCA	Prop. 2.9
	$k=55$	$C_3\times(C_4:C_8)$	CCA	Prop. 2.10

$n=96$	$k=56$	$C_3 \times (C_8 : C_4)$	Non-CCA	Prop. 2.9
	$k=57$	$C_3 \times (C_8 : C_4)$	Non-CCA	Prop. 2.9
	$k=58$	$C_3 \times (C_4.D_8)*$	CCA	Prop. 2.10
	$k=59$	$C_{48} \times C_2$	CCA	Prop. 2.12
	$k=60$	$C_3 \times (C_{16} : C_2)$	CCA	Prop. 2.10
	$k=61$	$C_3 \times D_{32}$	CCA	Prop. 2.10
	$k=62$	$C_3 \times QD_{32}$	Non-CCA	Prop. 2.9
	$k=63$	$C_3 \times Q_{32}$	Non-CCA	Prop. 2.9
	$k=64$	$((C_4 \times C_4) : C_3) : C_2$	Non-CCA	Prop. 2.3
	$k=65$	$A_4 : C_8$	Non-CCA	Prop. 2.3
	$k=66$	$SL(2,3) : C_4$	Non-CCA	Prop. 2.3
	$k=67$	$SL(2,3) : C_4$	Non-CCA	Prop. 2.3
	$k=68$	$C_2 \times ((C_4 \times C_4) : C_3)$	Non-CCA	
	$k=69$	$C_4 \times SL(2,3)$	Non-CCA	Prop. 2.9
	$k=70$	$((C_2 \times C_2 \times C_2 \times C_2) : C_3) : C_2$	Non-CCA	
	$k=71$	$((C_4 \times C_4) : C_3) : C_2$	Non-CCA	
	$k=72$	$((C_4 \times C_4) : C_3) : C_2$	CCA	
	$k=73$	$C_8 \times A_4$	Non-CCA	Prop. 2.3
	$k=74$	$((C_8 \times C_2) : C_2) : C_3$	Non-CCA	Prop. 2.3
	$k=75$	$C_4 \times (C_3 : Q_8)$	Non-CCA	Prop. 2.9
	$k=76$	$C_{12} : Q_8$	Non-CCA	Cor. 2.4
	$k=77$	$C_3 : ((C_2 \times C_2).(C_2 \times C_2 \times C_2))$	Non-CCA	Prop. 2.3
	$k=78$	$C_4 \times C_4 \times S_3$	Non-CCA	Prop. 2.9
	$k=79$	$(C_{12} \times C_4) : C_2$	Non-CCA	Prop. 2.3
	$k=80$	$C_4 \times D_{24}$	Non-CCA	Prop. 2.3
	$k=81$	$(C_{12} \times C_4) : C_2$	CCA	
	$k=82$	$(C_{12} \times C_4) : C_2$	Non-CCA	Prop. 2.3
	$k=83$	$(C_{12} \times C_4) : C_2$	Non-CCA	Prop. 2.3
	$k=84$	$(C_4 \times (C_3 : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k=85$	$(C_2 \times (C_3 : Q_8)) : C_2$	Non-CCA	Prop. 2.3
	$k=86$	$(C_4 \times (C_3 : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k=87$	$((C_4 \times C_2) : C_2) \times S_3$	Non-CCA	Prop. 2.9
	$k=88$	$(C_2 \times C_4 \times S_3) : C_2$	Non-CCA	Prop. 2.3
	$k=89$	$(C_2 \times C_2 \times C_2 \times S_3) : C_2$	Non-CCA	Prop. 2.3
	$k=90$	$(C_2 \times C_4 \times S_3) : C_2$	Non-CCA	Prop. 2.3
	$k=91$	$(C_2 \times C_4 \times S_3) : C_2$	Non-CCA	Prop. 2.3
	$k=92$	$(C_2 \times (C_3 : Q_8)) : C_2$	Non-CCA	Prop. 2.3
	$k=93$	$(C_2 \times C_2 \times (C_3 : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k=94$	$(C_3 : Q_8) : C_4$	Non-CCA	Prop. 2.3

	$k=95$	$C_{12}:Q_8$	Non-CCA	Prop. 2.3
	$k=96$	$C_3:((C_2\times C_2).(C_2\times C_2\times C_2))$	Non-CCA	Prop. 2.3
	$k=97$	$C_3:((C_2\times C_2).(C_2\times C_2\times C_2))$	Non-CCA	Prop. 2.3
	$k=98$	$(C_4:C_4)\times S_3$	Non-CCA	Prop. 2.9
	$k=99$	$(C_4\times(C_3:C_4)):C_2$	Non-CCA	Prop. 2.3
	$k=100$	$(C_2\times C_4\times S_3):C_2$	Non-CCA	Prop. 2.3
	$k=101$	$(C_2\times C_4\times S_3):C_2$	Non-CCA	Prop. 2.3
	$k=102$	$(C_2\times C_4\times S_3):C_2$	Non-CCA	Prop. 2.3
	$k=103$	$(C_2\times(C_3:Q_8)):C_2$	Non-CCA	Prop. 2.3
	$k=104$	$(C_3\times(C_4:C_4)):C_2$	Non-CCA	Prop. 2.3
	$k=105$	$(C_3\times(C_4:C_4)):C_2$	Non-CCA	Prop. 2.3
	$k=106$	$C_2\times C_8\times S_3$	Non-CCA	Prop. 2.9
	$k=107$	$C_2\times(C_{24}:C_2)$	Non-CCA	Prop. 2.9
	$k=108$	$(C_{24}\times C_2):C_2$	Non-CCA	Prop. 2.3
	$k=109$	$C_2\times(C_{24}:C_2)$	Non-CCA	Prop. 2.9
	$k=110$	$C_2\times D_{48}$	CCA	Prop. 2.15
	$k=111$	$(C_{24}\times C_2):C_2$	Non-CCA	Prop. 2.3
	$k=112$	$C_2\times(C_3:Q_{16})$	Non-CCA	Prop. 2.9
	$k=113$	$(C_8:C_2)\times S_3$	Non-CCA	Prop. 2.3
$n=96$	$k=114$	$(C_8\times S_3):C_2$	Non-CCA	Prop. 2.3
	$k=115$	$(C_2\times D_{24}):C_2$	Non-CCA	Prop. 2.3
	$k=116$	$(C_3\times(C_8:C_2)):C_2$	Non-CCA	Prop. 2.3
	$k=117$	$D_{16}\times S_3$	Non-CCA	Prop. 2.3
	$k=118$	$(D_8\times S_3):C_2$	Non-CCA	Prop. 2.3
	$k=119$	$(C_8\times S_3):C_2$	Non-CCA	Prop. 2.3
	$k=120$	$QD_{16}\times S_3$	Non-CCA	Prop. 2.9
	$k=121$	$(D_8\times S_3):C_2$	Non-CCA	Prop. 2.3
	$k=122$	$(Q_8\times S_3):C_2$	Non-CCA	Prop. 2.3
	$k=123$	$(C_8\times S_3):C_2$	Non-CCA	Prop. 2.3
	$k=124$	$Q_{16}\times S_3$	Non-CCA	Prop. 2.9
	$k=125$	$(C_3\times Q_{16}):C_2$	Non-CCA	Prop. 2.3
	$k=126$	$(C_8\times S_3):C_2$	Non-CCA	Prop. 2.3
	$k=127$	$C_2\times C_2\times(C_3:C_8)$	Non-CCA	Prop. 2.3
	$k=128$	$C_2\times((C_3:C_8):C_2)$	Non-CCA	Prop. 2.3
	$k=129$	$C_2\times C_4\times(C_3:C_4)$	Non-CCA	Prop. 2.9
	$k=130$	$C_2\times((C_3:C_4):C_4)$	Non-CCA	Prop. 2.9
	$k=131$	$(C_2\times(C_3:Q_8)):C_2$	Non-CCA	Prop. 2.3
	$k=132$	$C_2\times(C_{12}:C_4)$	Non-CCA	Prop. 2.9
	$k=133$	$(C_4\times(C_3:C_4)):C_2$	Non-CCA	Prop. 2.3

	$k = 134$	$C_2 \times ((C_{12} \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 135$	$C_4 \times ((C_6 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 136$	$(C_{12} \times C_2 \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 137$	$(C_{12} \times C_2 \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 138$	$C_2 \times ((C_3 \times D_8) : C_2)$	CCA	
	$k = 139$	$(C_6 \times D_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 140$	$C_2 \times ((C_3 : C_8) : C_2)$	Non-CCA	Prop. 2.3
	$k = 141$	$D_8 \times (C_3 : C_4)$	Non-CCA	Prop. 2.9
	$k = 142$	$(C_2 \times C_2 \times (C_3 : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k = 143$	$(C_2 \times (C_3 : Q_8)) : C_2$	Non-CCA	Prop. 2.3
	$k = 144$	$(C_2 \times C_2 \times C_2 \times S_3) : C_2$	Non-CCA	Prop. 2.3
	$k = 145$	$(C_6 \times D_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 146$	$(C_2 \times C_2 \times (C_3 : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k = 147$	$(C_6 \times D_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 148$	$C_2 \times ((C_3 \times Q_8) : C_2)$	Non-CCA	Prop. 2.9
	$k = 149$	$(C_6 \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 150$	$C_2 \times (C_3 : Q_{16})$	Non-CCA	Prop. 2.9
	$k = 151$	$(C_3 : C_4) : Q_8$	Non-CCA	Prop. 2.3
	$k = 152$	$Q_8 \times (C_3 : C_4)$	Non-CCA	Prop. 2.9
$n = 96$	$k = 153$	$(C_6 \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 154$	$(C_6 \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 155$	$(C_2 \times (C_3 : C_8)) : C_2$	Non-CCA	Prop. 2.3
	$k = 156$	$(C_2 \times D_{24}) : C_2$	Non-CCA	Prop. 2.3
	$k = 157$	$(C_2 \times (C_3 : C_8)) : C_2$	Non-CCA	Prop. 2.3
	$k = 158$	$(C_2 \times (C_3 : Q_8)) : C_2$	Non-CCA	Prop. 2.3
	$k = 159$	$C_2 \times ((C_2 \times (C_3 : C_4)) : C_2)$	Non-CCA	Prop. 2.9
	$k = 160$	$(C_6 \times C_2 \times C_2 \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 161$	$C_{12} \times C_4 \times C_2$	Non-CCA	Prop. 2.12
	$k = 162$	$C_6 \times ((C_4 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 163$	$C_6 \times (C_4 : C_4)$	Non-CCA	Prop. 2.9
	$k = 164$	$C_3 \times ((C_4 \times C_4) : C_2)$	Non-CCA	Prop. 2.9
	$k = 165$	$C_{12} \times D_8$	Non-CCA	Prop. 2.9
	$k = 166$	$C_{12} \times Q_8$	Non-CCA	Prop. 2.9
	$k = 167$	$C_3 \times ((C_2 \times C_2 \times C_2 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 168$	$C_3 \times ((C_4 \times C_2 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 169$	$C_3 \times ((C_2 \times Q_8) : C_2)$	Non-CCA	Prop. 2.9
	$k = 170$	$C_3 \times ((C_4 \times C_2 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 171$	$C_3 \times ((C_4 \times C_4) : C_2)$	Non-CCA	Prop. 2.9
	$k = 172$	$C_3 \times ((C_2 \times C_2).(C_2 \times C_2 \times C_2))$	Non-CCA	Prop. 2.9

$n = 96$	$k = 173$	$C_3 \times ((C_4 \times C_4) : C_2)$	Non-CCA	Prop. 2.9
	$k = 174$	$C_3 \times ((C_4 \times C_4) : C_2)$	CCA	Prop. 2.10
	$k = 175$	$C_3 \times (C_4 : Q_8)$	Non-CCA	Prop. 2.9
	$k = 176$	$C_{24} \times C_2 \times C_2$	Non-CCA	Prop. 2.12
	$k = 177$	$C_6 \times (C_8 : C_2)$	Non-CCA	Prop. 2.9
	$k = 178$	$C_3 \times ((C_8 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 179$	$C_6 \times D_{16}$	CCA	Prop. 2.10
	$k = 180$	$C_6 \times QD_{16}$	Non-CCA	Prop. 2.9
	$k = 181$	$C_6 \times Q_{16}$	Non-CCA	Prop. 2.9
	$k = 182$	$C_3 \times ((C_8 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 183$	$C_3 \times ((C_2 \times D_8) : C_2)$	Non-CCA	Prop. 2.9
	$k = 184$	$C_3 \times ((C_2 \times Q_8) : C_2)$	Non-CCA	Prop. 2.9
	$k = 185$	$A_4 : Q_8$	Non-CCA	Prop. 2.3
	$k = 186$	$C_4 \times S_4$	Non-CCA	Prop. 2.9
	$k = 187$	$(C_2 \times S_4) : C_2$	Non-CCA	Prop. 2.3
	$k = 188$	$C_2 \times (C_2.S_4)*$	Non-CCA	Prop. 2.9
	$k = 189$	$C_2 \times GL(2,3)$	Non-CCA	Prop. 2.9
	$k = 190$	$(C_2 \times SL(2,3)) : C_2$	Non-CCA	Prop. 2.3
	$k = 191$	$(C_2.S_4) : C_2*$	Non-CCA	Prop. 2.3
	$k = 192$	$(C_2.S_4) : C_2*$	Non-CCA	Prop. 2.3
	$k = 193$	$(SL(2,3) : C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 194$	$C_2 \times (A_4 : C_4)$	Non-CCA	Prop. 2.9
	$k = 195$	$(C_2 \times C_2 \times A_4) : C_2$	Non-CCA	Prop. 2.3
	$k = 196$	$C_2 \times C_4 \times A_4$	Non-CCA	Prop. 2.9
	$k = 197$	$D_8 \times A_4$	Non-CCA	Prop. 2.3
	$k = 198$	$C_2 \times C_2 \times SL(2,3)$	Non-CCA	Prop. 2.9
	$k = 199$	$Q_8 \times A_4$	Non-CCA	Prop. 2.9
	$k = 200$	$C_2 \times (SL(2,3) : C_2)$	Non-CCA	Prop. 2.9
	$k = 201$	$(SL(2,3) : C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 202$	$(C_2 \times SL(2,3)) : C_2$	Non-CCA	Prop. 2.3
	$k = 203$	$(C_2 \times C_2 \times Q_8) : C_3$	Non-CCA	Prop. 2.3
	$k = 204$	$((C_2 \times D_8) : C_2) : C_3$	Non-CCA	Prop. 2.3
	$k = 205$	$C_2 \times C_2 \times (C_3 : Q_8)$	Non-CCA	Prop. 2.9
	$k = 206$	$C_2 \times C_2 \times C_4 \times S_3$	Non-CCA	Prop. 2.9
	$k = 207$	$C_2 \times C_2 \times D_{24}$	Non-CCA	Prop. 2.15
	$k = 208$	$C_2 \times ((C_{12} \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 209$	$C_2 \times D_8 \times S_3$	Non-CCA	Prop. 2.9
	$k = 210$	$C_2 \times ((C_2 \times (C_3 : C_4)) : C_2)$	Non-CCA	Prop. 2.9
	$k = 211$	$(C_6 \times D_8) : C_2$	Non-CCA	Prop. 2.3

$n=96$	$k=212$	$C_2 \times Q_8 \times S_3$	Non-CCA	Prop. 2.9
	$k=213$	$C_2 \times ((C_4 \times S_3):C_2)$	Non-CCA	Prop. 2.9
	$k=214$	$(C_6 \times Q_8):C_2$	Non-CCA	Prop. 2.3
	$k=215$	$((C_4 \times C_2):C_2) \times S_3$	Non-CCA	Prop. 2.9
	$k=216$	$(D_8 \times S_3):C_2$	Non-CCA	Prop. 2.3
	$k=217$	$(Q_8 \times S_3):C_2$	Non-CCA	Prop. 2.3
	$k=218$	$C_2 \times C_2 \times C_2 \times (C_3:C_4)$	Non-CCA	Prop. 2.9
	$k=219$	$C_2 \times C_2 \times ((C_6 \times C_2):C_2)$	Non-CCA	Prop. 2.9
	$k=220$	$C_{12} \times C_2 \times C_2 \times C_2$	Non-CCA	Prop. 2.12
	$k=221$	$C_2 \times C_6 \times D_8$	Non-CCA	Prop. 2.9
	$k=222$	$C_2 \times C_6 \times Q_8$	Non-CCA	Prop. 2.9
	$k=223$	$C_6 \times ((C_4 \times C_2):C_2)$	Non-CCA	Prop. 2.9
	$k=224$	$C_3 \times ((C_2 \times D_8):C_2)$	Non-CCA	Prop. 2.9
	$k=225$	$C_3 \times ((C_2 \times Q_8):C_2)$	Non-CCA	Prop. 2.9
	$k=226$	$C_2 \times C_2 \times S_4$	Non-CCA	Prop. 2.9
	$k=227$	$((C_2 \times C_2 \times C_2 \times C_2):C_3):C_2$	Non-CCA	Prop. 2.3
	$k=228$	$C_2 \times C_2 \times C_2 \times A_4$	CCA	
	$k=229$	$C_2 \times ((C_2 \times C_2 \times C_2 \times C_2):C_3)$	CCA	
	$k=230$	$C_2 \times C_2 \times C_2 \times C_2 \times S_3$	CCA	Prop. 2.15
	$k=231$	$C_6 \times C_2 \times C_2 \times C_2 \times C_2$	CCA	Prop. 2.12
$n=98$	$k=1$	D_{98}	CCA	Cor. 2.16
	$k=2$	C_{98}	CCA	Prop. 2.12
	$k=3$	$C_7 \times D_{14}$	Non-CCA	
	$k=4$	$(C_7 \times C_7):C_2$	CCA	Prop. 2.15
	$k=5$	$C_{14} \times C_7$	CCA	Prop. 2.12
$n=100$	$k=1$	$C_{25}:C_4$	Non-CCA	Cor. 2.4
	$k=2$	C_{100}	CCA	Prop. 2.12
	$k=3$	$C_{25}:C_4$	Non-CCA	Prop. 2.3
	$k=4$	D_{100}	CCA	Cor. 2.16
	$k=5$	$C_{50} \times C_2$	CCA	Prop. 2.12
	$k=6$	$C_5 \times (C_5:C_4)$	Non-CCA	Prop. 2.9
	$k=7$	$(C_5 \times C_5):C_4$	Non-CCA	Cor. 2.4
	$k=8$	$C_{20} \times C_5$	CCA	Prop. 2.12
	$k=9$	$C_5 \times (C_5:C_4)$	Non-CCA	Prop. 2.9
	$k=10$	$(C_5 \times C_5):C_4$	Non-CCA	Prop. 2.3
	$k=11$	$(C_5 \times C_5):C_4$	Non-CCA	Prop. 2.3
	$k=12$	$(C_5 \times C_5):C_4$	Non-CCA	Prop. 2.3
	$k=13$	$D_{10} \times D_{10}$	Non-CCA	
	$k=14$	$C_{10} \times D_{10}$	Non-CCA	

$n=100$	$k=15$	$C_2\times((C_5\times C_5):C_2)$	CCA	Prop. 2.15
	$k=16$	$C_{10}\times C_{10}$	CCA	Prop. 2.12
$n=104$	$k=1$	$C_{13}:C_8$	CCA	
	$k=2$	C_{104}	CCA	Prop. 2.12
	$k=3$	$C_{13}:C_8$	Non-CCA	Prop. 2.3
	$k=4$	$C_{13}:Q_8$	Non-CCA	Cor. 2.4
	$k=5$	$C_4\times D_{26}$	Non-CCA	Prop. 2.3
	$k=6$	D_{104}	CCA	Cor. 2.16
	$k=7$	$C_2\times(C_{13}:C_4)$	Non-CCA	Prop. 2.9
	$k=8$	$(C_{26}\times C_2):C_2$	Non-CCA	Prop. 2.3
	$k=9$	$C_{52}\times C_2$	Non-CCA	Prop. 2.12
	$k=10$	$C_{13}\times D_8$	CCA	Prop. 2.10
	$k=11$	$C_{13}\times Q_8$	Non-CCA	Prop. 2.9
	$k=12$	$C_2\times(C_{13}:C_4)$	Non-CCA	Prop. 2.9
	$k=13$	$C_2\times C_2\times D_{26}$	CCA	Prop. 2.15
	$k=14$	$C_{26}\times C_2\times C_2$	CCA	Prop. 2.12
$n=105$	$k=1$	$C_5\times(C_7:C_3)$	Non-CCA	Prop. 2.9
	$k=2$	C_{105}	CCA	Prop. 2.12
$n=108$	$k=1$	$C_{27}:C_4$	Non-CCA	Cor. 2.4
	$k=2$	C_{108}	CCA	Prop. 2.12
	$k=3$	$(C_2\times C_2):C_{27}$	CCA	
	$k=4$	D_{108}	CCA	Cor. 2.16
	$k=5$	$C_{54}\times C_2$	CCA	Prop. 2.12
	$k=6$	$C_3\times(C_9:C_4)$	Non-CCA	Prop. 2.9
	$k=7$	$C_9\times(C_3:C_4)$	Non-CCA	Prop. 2.9
	$k=8$	$((C_3\times C_3):C_4):C_3$	Non-CCA	Prop. 2.3
	$k=9$	$(C_9:C_4):C_3$	Non-CCA	Prop. 2.3
	$k=10$	$(C_9\times C_3):C_4$	Non-CCA	Cor. 2.4
	$k=11$	$((C_3\times C_3):C_3):C_4$	Non-CCA	Prop. 2.3
	$k=12$	$C_{36}\times C_3$	CCA	Prop. 2.12
	$k=13$	$C_4\times((C_3\times C_3):C_3)$	CCA	Prop. 2.10
	$k=14$	$C_4\times(C_9:C_3)$	CCA	Prop. 2.10
	$k=15$	$((C_3\times C_3):C_3):C_4$	Non-CCA	Prop. 2.3
	$k=16$	$S_3\times D_{18}$	CCA	
	$k=17$	$(((C_3\times C_3):C_3):C_2):C_2$	Non-CCA	
	$k=18$	$C_9\times A_4$	CCA	
	$k=19$	$(C_{18}\times C_2):C_3$	CCA	
	$k=20$	$C_3\times((C_2\times C_2):C_9)$	CCA	
	$k=21$	$((C_2\times C_2):C_9):C_3$	CCA	

$n=108$	$k=22$	$(C_6 \times C_6) : C_3$	CCA	
	$k=23$	$C_6 \times D_{18}$	CCA	
	$k=24$	$C_{18} \times S_3$	CCA	
	$k=25$	$C_2 \times (((C_3 \times C_3) : C_3) : C_2)$	Non-CCA	Prop. 2.9
	$k=26$	$C_2 \times ((C_9 : C_3) : C_2)$	CCA	
	$k=27$	$C_2 \times ((C_9 \times C_3) : C_2)$	CCA	Prop. 2.15
	$k=28$	$C_2 \times (((C_3 \times C_3) : C_3) : C_2)$	CCA	
	$k=29$	$C_{18} \times C_6$	CCA	Prop. 2.12
	$k=30$	$C_2 \times C_2 \times ((C_3 \times C_3) : C_3)$	CCA	Prop. 2.10
	$k=31$	$C_2 \times C_2 \times (C_9 : C_3)$	CCA	Prop. 2.10
	$k=32$	$C_3 \times C_3 \times (C_3 : C_4)$	Non-CCA	Prop. 2.9
	$k=33$	$C_3 \times ((C_3 \times C_3) : C_4)$	Non-CCA	Prop. 2.9
	$k=34$	$(C_3 \times C_3 \times C_3) : C_4$	Non-CCA	Cor. 2.4
	$k=35$	$C_{12} \times C_3 \times C_3$	CCA	Prop. 2.12
	$k=36$	$C_3 \times ((C_3 \times C_3) : C_4)$	Non-CCA	Prop. 2.9
	$k=37$	$(C_3 \times C_3 \times C_3) : C_4$	Non-CCA	Prop. 2.3
	$k=38$	$C_3 \times S_3 \times S_3$	Non-CCA	Prop. 2.9
	$k=39$	$((C_3 \times C_3) : C_2) \times S_3$	Non-CCA	
	$k=40$	$(C_3 \times ((C_3 \times C_3) : C_2)) : C_2$	Non-CCA	
	$k=41$	$C_3 \times C_3 \times A_4$	CCA	
	$k=42$	$C_3 \times C_6 \times S_3$	Non-CCA	Prop. 2.9
	$k=43$	$C_6 \times ((C_3 \times C_3) : C_2)$	Non-CCA	
	$k=44$	$C_2 \times ((C_3 \times C_3 \times C_3) : C_2)$	CCA	Prop. 2.15
	$k=45$	$C_6 \times C_6 \times C_3$	CCA	Prop. 2.12
$n=112$	$k=1$	$C_7 : C_{16}$	CCA	
	$k=2$	C_{112}	CCA	Prop. 2.12
	$k=3$	$C_8 \times D_{14}$	Non-CCA	Prop. 2.3
	$k=4$	$C_{56} : C_2$	Non-CCA	Prop. 2.3
	$k=5$	$C_{56} : C_2$	Non-CCA	Prop. 2.3
	$k=6$	D_{112}	CCA	Cor. 2.16
	$k=7$	$C_7 : Q_{16}$	Non-CCA	Cor. 2.4
	$k=8$	$C_2 \times (C_7 : C_8)$	CCA	
	$k=9$	$(C_7 : C_8) : C_2$	CCA	
	$k=10$	$C_4 \times (C_7 : C_4)$	Non-CCA	Prop. 2.9
	$k=11$	$(C_7 : C_4) : C_4$	Non-CCA	Prop. 2.3
	$k=12$	$C_{28} : C_4$	Non-CCA	Cor. 2.4
	$k=13$	$(C_{28} \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k=14$	$(C_7 \times D_8) : C_2$	CCA	
	$k=15$	$(C_7 : C_8) : C_2$	Non-CCA	Prop. 2.3

$n=112$	$k=16$	$(C_7 \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k=17$	$C_7 : Q_{16}$	Non-CCA	Prop. 2.3
	$k=18$	$(C_2 \times (C_7 : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k=19$	$C_{28} \times C_4$	CCA	Prop. 2.12
	$k=20$	$C_7 \times ((C_4 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k=21$	$C_7 \times (C_4 : C_4)$	Non-CCA	Prop. 2.9
	$k=22$	$C_{56} \times C_2$	CCA	Prop. 2.12
	$k=23$	$C_7 \times (C_8 : C_2)$	CCA	Prop. 2.10
	$k=24$	$C_7 \times D_{16}$	CCA	Prop. 2.10
	$k=25$	$C_7 \times QD_{16}$	Non-CCA	Prop. 2.9
	$k=26$	$C_7 \times Q_{16}$	Non-CCA	Prop. 2.9
	$k=27$	$C_2 \times (C_7 : Q_8)$	Non-CCA	Prop. 2.9
	$k=28$	$C_2 \times C_4 \times D_{14}$	Non-CCA	Prop. 2.9
	$k=29$	$C_2 \times D_{56}$	Non-CCA	Prop. 2.15
	$k=30$	$(C_{28} \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k=31$	$D_8 \times D_{14}$	Non-CCA	Prop. 2.3
	$k=32$	$(C_2 \times (C_7 : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k=33$	$Q_8 \times D_{14}$	Non-CCA	Prop. 2.9
	$k=34$	$(C_4 \times D_{14}) : C_2$	Non-CCA	Prop. 2.3
	$k=35$	$C_2 \times C_2 \times (C_7 : C_4)$	Non-CCA	Prop. 2.9
	$k=36$	$C_2 \times ((C_{14} \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k=37$	$C_{28} \times C_2 \times C_2$	Non-CCA	Prop. 2.12
	$k=38$	$C_{14} \times D_8$	Non-CCA	Prop. 2.9
	$k=39$	$C_{14} \times Q_8$	Non-CCA	Prop. 2.9
	$k=40$	$C_7 \times ((C_4 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k=41$	$C_2 \times ((C_2 \times C_2 \times C_2) : C_7)$	CCA	
	$k=42$	$C_2 \times C_2 \times C_2 \times D_{14}$	CCA	Prop. 2.15
	$k=43$	$C_{14} \times C_2 \times C_2 \times C_2$	CCA	Prop. 2.12
$n=116$	$k=1$	$C_{29} : C_4$	Non-CCA	Cor. 2.4
	$k=2$	C_{116}	CCA	Prop. 2.12
	$k=3$	$C_{29} : C_4$	Non-CCA	Prop. 2.3
	$k=4$	D_{116}	CCA	Cor. 2.16
	$k=5$	$C_{58} \times C_2$	CCA	Prop. 2.12
$n=120$	$k=1$	$C_5 \times (C_3 : C_8)$	CCA	Prop. 2.10
	$k=2$	$C_3 \times (C_5 : C_8)$	CCA	Prop. 2.10
	$k=3$	$C_{15} : C_8$	CCA	
	$k=4$	C_{120}	CCA	Prop. 2.12
	$k=5$	$SL(2,5)$	Non-CCA	Prop. 2.3
	$k=6$	$C_3 \times (C_5 : C_8)$	Non-CCA	Prop. 2.9

$n=120$	$k=7$	$C_{15}:C_8$	Non-CCA	Prop. 2.3
	$k=8$	$(C_3:C_4)\times D_{10}$	Non-CCA	Prop. 2.9
	$k=9$	$S_3\times(C_5:C_4)$	Non-CCA	Prop. 2.9
	$k=10$	$(C_5\times(C_3:C_4)):C_2$	Non-CCA	Prop. 2.3
	$k=11$	$(C_{10}\times S_3):C_2$	Non-CCA	Prop. 2.3
	$k=12$	$(C_6\times D_{10}):C_2$	Non-CCA	Prop. 2.3
	$k=13$	$(C_{10}\times S_3):C_2$	Non-CCA	Prop. 2.3
	$k=14$	$C_{15}:Q_8$	Non-CCA	Prop. 2.3
	$k=15$	$C_5\times SL(2,3)$	Non-CCA	Prop. 2.9
	$k=16$	$C_3\times(C_5:Q_8)$	Non-CCA	Prop. 2.9
	$k=17$	$C_{12}\times D_{10}$	Non-CCA	Prop. 2.9
	$k=18$	$C_3\times D_{40}$	CCA	Prop. 2.10
	$k=19$	$C_6\times(C_5:C_4)$	Non-CCA	Prop. 2.9
	$k=20$	$C_3\times((C_{10}\times C_2):C_2)$	Non-CCA	Prop. 2.9
	$k=21$	$C_5\times(C_3:Q_8)$	Non-CCA	Prop. 2.9
	$k=22$	$C_{20}\times S_3$	Non-CCA	Prop. 2.9
	$k=23$	$C_5\times D_{24}$	CCA	Prop. 2.10
	$k=24$	$C_{10}\times(C_3:C_4)$	Non-CCA	Prop. 2.9
	$k=25$	$C_5\times((C_6\times C_2):C_2)$	Non-CCA	Prop. 2.9
	$k=26$	$C_{15}:Q_8$	Non-CCA	Cor. 2.4
	$k=27$	$C_4\times D_{30}$	Non-CCA	Prop. 2.3
	$k=28$	D_{120}	CCA	Cor. 2.16
	$k=29$	$C_2\times(C_{15}:C_4)$	Non-CCA	Prop. 2.9
	$k=30$	$(C_{30}\times C_2):C_2$	Non-CCA	Prop. 2.3
	$k=31$	$C_{60}\times C_2$	Non-CCA	Prop. 2.12
	$k=32$	$C_{15}\times D_8$	CCA	Prop. 2.10
	$k=33$	$C_{15}\times Q_8$	Non-CCA	Prop. 2.9
	$k=34$	S_5	Non-CCA	Prop. 2.3
	$k=35$	$C_2\times A_5$	Non-CCA	
	$k=36$	$S_3\times(C_5:C_4)$	Non-CCA	Prop. 2.9
	$k=37$	$C_5\times S_4$	Non-CCA	Prop. 2.9
	$k=38$	$(C_5\times A_4):C_2$	Non-CCA	Prop. 2.3
	$k=39$	$A_4\times D_{10}$	CCA	
	$k=40$	$C_6\times(C_5:C_4)$	Non-CCA	Prop. 2.9
	$k=41$	$C_2\times(C_{15}:C_4)$	Non-CCA	Prop. 2.9
	$k=42$	$C_2\times S_3\times D_{10}$	CCA	
	$k=43$	$C_{10}\times A_4$	CCA	Prop. 2.10
	$k=44$	$C_2\times C_6\times D_{10}$	CCA	Prop. 2.10
	$k=45$	$C_2\times C_{10}\times S_3$	CCA	Prop. 2.10

$n = 120$	$k = 46$	$C_2 \times C_2 \times D_{30}$	CCA	Prop. 2.15
	$k = 47$	$C_{30} \times C_2 \times C_2$	CCA	Prop. 2.12
$n = 124$	$k = 1$	$C_{31} : C_4$	Non-CCA	Cor. 2.4
	$k = 2$	C_{124}	CCA	Prop. 2.12
	$k = 3$	D_{124}	CCA	Cor. 2.16
	$k = 4$	$C_{62} \times C_2$	CCA	Prop. 2.12
$n = 126$	$k = 1$	$(C_7 : C_9) : C_2$	CCA	
	$k = 2$	$C_2 \times (C_7 : C_9)$	CCA	Prop. 2.10
	$k = 3$	$C_7 \times D_{18}$	CCA	Prop. 2.10
	$k = 4$	$C_9 \times D_{14}$	CCA	Prop. 2.10
	$k = 5$	D_{126}	CCA	Cor. 2.16
	$k = 6$	C_{126}	CCA	Prop. 2.12
	$k = 7$	$C_3 \times ((C_7 : C_3) : C_2)$	Non-CCA	Prop. 2.9
	$k = 8$	$S_3 \times (C_7 : C_3)$	Non-CCA	Prop. 2.9
	$k = 9$	$(C_3 \times (C_7 : C_3)) : C_2$	Non-CCA	
	$k = 10$	$C_6 \times (C_7 : C_3)$	Non-CCA	Prop. 2.9
	$k = 11$	$C_3 \times C_3 \times D_{14}$	CCA	Prop. 2.10
	$k = 12$	$C_{21} \times S_3$	Non-CCA	Prop. 2.9
	$k = 13$	$C_3 \times D_{42}$	Non-CCA	
	$k = 14$	$C_7 \times ((C_3 \times C_3) : C_2)$	CCA	Prop. 2.10
	$k = 15$	$(C_{21} \times C_3) : C_2$	CCA	Prop. 2.15
	$k = 16$	$C_{42} \times C_3$	CCA	Prop. 2.12
$n = 132$	$k = 1$	$C_{11} \times (C_3 : C_4)$	Non-CCA	Prop. 2.9
	$k = 2$	$C_3 \times (C_{11} : C_4)$	Non-CCA	Prop. 2.9
	$k = 3$	$C_{33} : C_4$	Non-CCA	Cor. 2.4
	$k = 4$	C_{132}	CCA	Prop. 2.12
	$k = 5$	$S_3 \times D_{22}$	CCA	
	$k = 6$	$C_{11} \times A_4$	CCA	Prop. 2.10
	$k = 7$	$C_6 \times D_{22}$	CCA	Prop. 2.10
	$k = 8$	$C_{22} \times S_3$	CCA	Prop. 2.10
	$k = 9$	D_{132}	CCA	Cor. 2.16
	$k = 10$	$C_{66} \times C_2$	CCA	Prop. 2.12
$n = 136$	$k = 1$	$C_{17} : C_8$	CCA	
	$k = 2$	C_{136}	CCA	Prop. 2.12
	$k = 3$	$C_{17} : C_8$	Non-CCA	Prop. 2.3
	$k = 4$	$C_{17} : Q_8$	Non-CCA	Cor. 2.4
	$k = 5$	$C_4 \times D_{34}$	Non-CCA	Prop. 2.3
	$k = 6$	D_{136}	CCA	Cor. 2.16
	$k = 7$	$C_2 \times (C_{17} : C_4)$	Non-CCA	Prop. 2.9

$n = 136$	$k = 8$	$(C_{34} \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 9$	$C_{68} \times C_2$	Non-CCA	Prop. 2.12
	$k = 10$	$C_{17} \times D_8$	CCA	Prop. 2.10
	$k = 11$	$C_{17} \times Q_8$	Non-CCA	Prop. 2.9
	$k = 12$	$C_{17} : C_8$	CCA	
	$k = 13$	$C_2 \times (C_{17} : C_4)$	Non-CCA	Prop. 2.9
	$k = 14$	$C_2 \times C_2 \times D_{34}$	CCA	Prop. 2.15
	$k = 15$	$C_{34} \times C_2 \times C_2$	CCA	Prop. 2.12
$n = 140$	$k = 1$	$C_7 \times (C_5 : C_4)$	Non-CCA	Prop. 2.9
	$k = 2$	$C_5 \times (C_7 : C_4)$	Non-CCA	Prop. 2.9
	$k = 3$	$C_{35} : C_4$	Non-CCA	Cor. 2.4
	$k = 4$	C_{140}	CCA	Prop. 2.12
	$k = 5$	$C_7 \times (C_5 : C_4)$	Non-CCA	Prop. 2.9
	$k = 6$	$C_{35} : C_4$	Non-CCA	Prop. 2.3
	$k = 7$	$D_{10} \times D_{14}$	CCA	
	$k = 8$	$C_{10} \times D_{14}$	CCA	Prop. 2.10
	$k = 9$	$C_{14} \times D_{10}$	CCA	Prop. 2.10
	$k = 10$	D_{140}	CCA	Cor. 2.16
	$k = 11$	$C_{70} \times C_2$	CCA	Prop. 2.12
$n = 144$	$k = 1$	$C_9 : C_{16}$	CCA	
	$k = 2$	C_{144}	CCA	Prop. 2.12
	$k = 3$	$(C_4 \times C_4) : C_9$	CCA	
	$k = 4$	$C_9 : Q_{16}$	Non-CCA	Cor. 2.4
	$k = 5$	$C_8 \times D_{18}$	Non-CCA	Prop. 2.3
	$k = 6$	$C_{72} : C_2$	Non-CCA	Prop. 2.3
	$k = 7$	$C_{72} : C_2$	Non-CCA	Prop. 2.3
	$k = 8$	D_{144}	CCA	Cor. 2.16
	$k = 9$	$C_2 \times (C_9 : C_8)$	CCA	
	$k = 10$	$(C_9 : C_8) : C_2$	CCA	
	$k = 11$	$C_4 \times (C_9 : C_4)$	Non-CCA	Prop. 2.9
	$k = 12$	$(C_9 : C_4) : C_4$	Non-CCA	Prop. 2.3
	$k = 13$	$C_{36} : C_4$	Non-CCA	Cor. 2.4
	$k = 14$	$(C_{36} \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 15$	$(C_9 : Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 16$	$(C_9 \times D_8) : C_2$	CCA	
	$k = 17$	$C_9 : Q_{16}$	Non-CCA	Prop. 2.3
	$k = 18$	$(C_9 \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 19$	$(C_2 \times (C_9 : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k = 20$	$C_{36} \times C_4$	CCA	Prop. 2.12

$n = 144$	$k = 21$	$C_9 \times ((C_4 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 22$	$C_9 \times (C_4 : C_4)$	Non-CCA	Prop. 2.9
	$k = 23$	$C_{72} \times C_2$	CCA	Prop. 2.12
	$k = 24$	$C_9 \times (C_8 : C_2)$	CCA	Prop. 2.10
	$k = 25$	$C_9 \times D_{16}$	CCA	Prop. 2.10
	$k = 26$	$C_9 \times QD_{16}$	Non-CCA	Prop. 2.9
	$k = 27$	$C_9 \times Q_{16}$	Non-CCA	Prop. 2.9
	$k = 28$	$C_3 \times (C_3 : C_{16})$	Non-CCA	
	$k = 29$	$(C_3 \times C_3) : C_{16}$	CCA	
	$k = 30$	$C_{48} \times C_3$	CCA	Prop. 2.12
	$k = 31$	$(Q_8 : C_9).C_2*$	Non-CCA	Prop. 2.3
	$k = 32$	$(Q_8 : C_9) : C_2$	Non-CCA	Prop. 2.3
	$k = 33$	$((C_2 \times C_2) : C_9) : C_4$	Non-CCA	Prop. 2.3
	$k = 34$	$C_4 \times ((C_2 \times C_2) : C_9)$	Non-CCA	Prop. 2.3
	$k = 35$	$C_2 \times (Q_8 : C_9)$	Non-CCA	Prop. 2.9
	$k = 36$	$(Q_8 : C_9) : C_2$	Non-CCA	Prop. 2.3
	$k = 37$	$C_2 \times (C_9 : Q_8)$	Non-CCA	Prop. 2.9
	$k = 38$	$C_2 \times C_4 \times D_{18}$	Non-CCA	Prop. 2.3
	$k = 39$	$C_2 \times D_{72}$	Non-CCA	Prop. 2.15
	$k = 40$	$(C_{36} \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 41$	$D_8 \times D_{18}$	Non-CCA	Prop. 2.3
	$k = 42$	$(C_2 \times (C_9 : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k = 43$	$Q_8 \times D_{18}$	Non-CCA	Prop. 2.9
	$k = 44$	$(C_4 \times D_{18}) : C_2$	Non-CCA	Prop. 2.3
	$k = 45$	$C_2 \times C_2 \times (C_9 : C_4)$	Non-CCA	Prop. 2.9
	$k = 46$	$C_2 \times ((C_{18} \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 47$	$C_{36} \times C_2 \times C_2$	Non-CCA	Prop. 2.12
	$k = 48$	$C_{18} \times D_8$	Non-CCA	Prop. 2.9
	$k = 49$	$C_{18} \times Q_8$	Non-CCA	Prop. 2.9
	$k = 50$	$C_9 \times ((C_4 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 51$	$(C_3 \times C_3) : C_{16}$	Non-CCA	
	$k = 52$	$(C_3 : C_8) \times S_3$	Non-CCA	Prop. 2.3
	$k = 53$	$(C_3 \times (C_3 : C_8)) : C_2$	Non-CCA	Prop. 2.3
	$k = 54$	$(C_3 \times (C_3 : C_8)) : C_2$	Non-CCA	Prop. 2.3
	$k = 55$	$(C_3 \times (C_3 : C_8)) : C_2$	Non-CCA	Prop. 2.3
	$k = 56$	$(C_3 \times D_{24}) : C_2$	Non-CCA	
	$k = 57$	$(C_3 \times (C_3 : C_8)) : C_2$	Non-CCA	
	$k = 58$	$(C_3 \times (C_3 : Q_8)) : C_2$	Non-CCA	Prop. 2.3
	$k = 59$	$(C_3 \times (C_3 : C_8)) : C_2$	Non-CCA	Prop. 2.3

$n=144$	$k=60$	$(C_3\times(C_3:Q_8)):C_2$	Non-CCA	Prop. 2.3
	$k=61$	$(C_3\times C_3):Q_{16}$	Non-CCA	Prop. 2.3
	$k=62$	$(C_3\times C_3):Q_{16}$	Non-CCA	Prop. 2.3
	$k=63$	$(C_3:C_4)\times(C_3:C_4)$	Non-CCA	Prop. 2.9
	$k=64$	$(C_6\times(C_3:C_4)):C_2$	Non-CCA	Prop. 2.3
	$k=65$	$(C_6\times(C_3:C_4)):C_2$	Non-CCA	Prop. 2.3
	$k=66$	$(C_3\times(C_3:C_4)):C_4$	Non-CCA	Prop. 2.3
	$k=67$	$((C_3\times C_3):C_4):C_4$	Non-CCA	Prop. 2.3
	$k=68$	$C_3\times((C_4\times C_4):C_3)$	CCA	
	$k=69$	$C_{24}\times S_3$	Non-CCA	Prop. 2.3
	$k=70$	$C_3\times(C_{24}:C_2)$	Non-CCA	Prop. 2.9
	$k=71$	$C_3\times(C_{24}:C_2)$	Non-CCA	Prop. 2.9
	$k=72$	$C_3\times D_{48}$	Non-CCA	
	$k=73$	$C_3\times(C_3:Q_{16})$	Non-CCA	Prop. 2.9
	$k=74$	$C_6\times(C_3:C_8)$	Non-CCA	
	$k=75$	$C_3\times((C_3:C_8):C_2)$	Non-CCA	
	$k=76$	$C_{12}\times(C_3:C_4)$	Non-CCA	Prop. 2.9
	$k=77$	$C_3\times((C_3:C_4):C_4)$	Non-CCA	Prop. 2.9
	$k=78$	$C_3\times(C_{12}:C_4)$	Non-CCA	Prop. 2.9
	$k=79$	$C_3\times((C_{12}\times C_2):C_2)$	Non-CCA	Prop. 2.9
	$k=80$	$C_3\times((C_3\times D_8):C_2)$	Non-CCA	
	$k=81$	$C_3\times((C_3:C_8):C_2)$	Non-CCA	Prop. 2.3
	$k=82$	$C_3\times((C_3\times Q_8):C_2)$	Non-CCA	Prop. 2.9
	$k=83$	$C_3\times(C_3:Q_{16})$	Non-CCA	Prop. 2.9
	$k=84$	$C_3\times((C_2\times(C_3:C_4)):C_2)$	Non-CCA	Prop. 2.9
	$k=85$	$C_8\times((C_3\times C_3):C_2)$	Non-CCA	Prop. 2.3
	$k=86$	$(C_{24}\times C_3):C_2$	Non-CCA	Prop. 2.15
	$k=87$	$(C_{24}\times C_3):C_2$	Non-CCA	Prop. 2.3
	$k=88$	$(C_{24}\times C_3):C_2$	CCA	
	$k=89$	$(C_3\times C_3):Q_{16}$	Non-CCA	Cor. 2.4
	$k=90$	$C_2\times((C_3\times C_3):C_8)$	CCA	
	$k=91$	$((C_3\times C_3):C_8):C_2$	CCA	
	$k=92$	$C_4\times((C_3\times C_3):C_4)$	Non-CCA	Prop. 2.9
	$k=93$	$((C_3\times C_3):C_4):C_4$	Non-CCA	Prop. 2.3
	$k=94$	$(C_{12}\times C_3):C_4$	Non-CCA	Cor. 2.4
	$k=95$	$(C_{12}\times C_6):C_2$	Non-CCA	Prop. 2.3
	$k=96$	$(C_3\times C_3\times D_8):C_2$	CCA	
	$k=97$	$((C_3\times C_3):Q_8):C_2$	Non-CCA	Prop. 2.3
	$k=98$	$(C_3\times C_3\times Q_8):C_2$	Non-CCA	Prop. 2.3

$n = 144$	$k = 99$	$(C_3 \times C_3) : Q_{16}$	Non-CCA	Prop. 2.3
	$k = 100$	$(C_2 \times ((C_3 \times C_3) : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k = 101$	$C_{12} \times C_{12}$	CCA	Prop. 2.12
	$k = 102$	$C_3 \times C_3 \times ((C_4 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 103$	$C_3 \times C_3 \times (C_4 : C_4)$	Non-CCA	Prop. 2.9
	$k = 104$	$C_{24} \times C_6$	CCA	Prop. 2.12
	$k = 105$	$C_3 \times C_3 \times (C_8 : C_2)$	CCA	Prop. 2.10
	$k = 106$	$C_3 \times C_3 \times D_{16}$	CCA	Prop. 2.10
	$k = 107$	$C_3 \times C_3 \times QD_{16}$	Non-CCA	Prop. 2.9
	$k = 108$	$C_3 \times C_3 \times Q_{16}$	Non-CCA	Prop. 2.9
	$k = 109$	$C_2 \times (((C_2 \times C_2) : C_9) : C_2)$	Non-CCA	Prop. 2.9
	$k = 110$	$C_2 \times C_2 \times ((C_2 \times C_2) : C_9)$	CCA	
	$k = 111$	$(C_2 \times C_2 \times C_2 \times C_2) : C_9$	CCA	
	$k = 112$	$C_2 \times C_2 \times C_2 \times D_{18}$	CCA	Prop. 2.15
	$k = 113$	$C_{18} \times C_2 \times C_2 \times C_2$	CCA	Prop. 2.12
	$k = 114$	$(C_3 \times C_3) : C_{16}$	Non-CCA	Prop. 2.3
	$k = 115$	$(C_2 \times ((C_3 \times C_3) : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k = 116$	$((C_3 \times C_3) : C_4) : C_4$	Non-CCA	Prop. 2.3
	$k = 117$	$((C_3 \times C_3) : C_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 118$	$((C_3 \times C_3) : Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 119$	$(C_3 \times C_3) : Q_{16}$	Non-CCA	Prop. 2.3
	$k = 120$	$((C_3 \times C_3) : C_4) : C_4$	Non-CCA	Prop. 2.3
	$k = 121$	$C_3 \times (C_2.S_4)*$	Non-CCA	Prop. 2.9
	$k = 122$	$C_3 \times GL(2,3)$	Non-CCA	Prop. 2.9
	$k = 123$	$C_3 \times (A_4 : C_4)$	Non-CCA	Prop. 2.9
	$k = 124$	$C_3 : (C_2.S_4)*$	Non-CCA	Prop. 2.3
	$k = 125$	$(C_3 \times SL(2,3)) : C_2$	Non-CCA	Prop. 2.3
	$k = 126$	$(C_3 \times A_4) : C_4$	Non-CCA	Prop. 2.3
	$k = 127$	$(C_3 \times SL(2,3)) : C_2$	Non-CCA	Prop. 2.3
	$k = 128$	$S_3 \times SL(2,3)$	Non-CCA	Prop. 2.9
	$k = 129$	$A_4 \times (C_3 : C_4)$	Non-CCA	Prop. 2.9
	$k = 130$	$((C_3 \times C_3) : C_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 131$	$((C_3 \times C_3) : C_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 132$	$C_4 \times ((C_3 \times C_3) : C_4)$	Non-CCA	Prop. 2.9
	$k = 133$	$(C_{12} \times C_3) : C_4$	Non-CCA	Prop. 2.3
	$k = 134$	$C_2 \times ((C_3 \times C_3) : C_8)$	Non-CCA	Prop. 2.3
	$k = 135$	$((C_3 \times C_3) : C_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 136$	$(C_2 \times ((C_3 \times C_3) : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k = 137$	$(C_3 : Q_8) \times S_3$	Non-CCA	Prop. 2.9

$n = 144$	$k = 138$	$(C_{12} \times S_3) : C_2$	Non-CCA	Prop. 2.3
	$k = 139$	$(C_4 \times ((C_3 \times C_3) : C_2)) : C_2$	Non-CCA	Prop. 2.3
	$k = 140$	$(C_3 \times (C_3 : Q_8)) : C_2$	Non-CCA	Prop. 2.3
	$k = 141$	$(C_{12} \times S_3) : C_2$	Non-CCA	Prop. 2.3
	$k = 142$	$(C_{12} \times S_3) : C_2$	Non-CCA	Prop. 2.3
	$k = 143$	$C_4 \times S_3 \times S_3$	Non-CCA	Prop. 2.9
	$k = 144$	$D_{24} \times S_3$	Non-CCA	Prop. 2.3
	$k = 145$	$(C_2 \times S_3 \times S_3) : C_2$	Non-CCA	Prop. 2.9
	$k = 146$	$C_2 \times ((C_3 : C_4) \times S_3)$	Non-CCA	Prop. 2.9
	$k = 147$	$(C_6 \times (C_3 : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k = 148$	$(C_2 \times ((C_3 \times C_3) : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k = 149$	$C_2 \times ((C_3 \times (C_3 : C_4)) : C_2)$	Non-CCA	Prop. 2.9
	$k = 150$	$C_2 \times ((C_6 \times S_3) : C_2)$	Non-CCA	Prop. 2.9
	$k = 151$	$C_2 \times ((C_6 \times S_3) : C_2)$	Non-CCA	Prop. 2.9
	$k = 152$	$C_2 \times ((C_3 \times C_3) : Q_8)$	Non-CCA	Prop. 2.9
	$k = 153$	$((C_6 \times C_2) : C_2) \times S_3$	Non-CCA	Prop. 2.9
	$k = 154$	$(C_2 \times S_3 \times S_3) : C_2$	Non-CCA	Prop. 2.3
	$k = 155$	$C_{12} \times A_4$	Non-CCA	Prop. 2.9
	$k = 156$	$C_6 \times SL(2,3)$	Non-CCA	Prop. 2.9
	$k = 157$	$C_3 \times (SL(2,3) : C_2)$	Non-CCA	Prop. 2.9
	$k = 158$	$C_6 \times (C_3 : Q_8)$	Non-CCA	Prop. 2.9
	$k = 159$	$C_2 \times C_{12} \times S_3$	Non-CCA	Prop. 2.9
	$k = 160$	$C_6 \times D_{24}$	Non-CCA	Prop. 2.9
	$k = 161$	$C_3 \times ((C_{12} \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 162$	$C_3 \times D_8 \times S_3$	Non-CCA	Prop. 2.9
	$k = 163$	$C_3 \times ((C_2 \times (C_3 : C_4)) : C_2)$	Non-CCA	Prop. 2.9
	$k = 164$	$C_3 \times Q_8 \times S_3$	Non-CCA	Prop. 2.9
	$k = 165$	$C_3 \times ((C_4 \times S_3) : C_2)$	Non-CCA	Prop. 2.9
	$k = 166$	$C_2 \times C_6 \times (C_3 : C_4)$	Non-CCA	Prop. 2.9
	$k = 167$	$C_6 \times ((C_6 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 168$	$C_2 \times ((C_3 \times C_3) : Q_8)$	Non-CCA	Prop. 2.9
	$k = 169$	$C_2 \times C_4 \times ((C_3 \times C_3) : C_2)$	Non-CCA	Prop. 2.3
	$k = 170$	$C_2 \times ((C_{12} \times C_3) : C_2)$	Non-CCA	Prop. 2.15
	$k = 171$	$(C_{12} \times C_6) : C_2$	Non-CCA	Prop. 2.3
	$k = 172$	$D_8 \times ((C_3 \times C_3) : C_2)$	Non-CCA	Prop. 2.3
	$k = 173$	$(C_3 \times C_3 \times D_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 174$	$Q_8 \times ((C_3 \times C_3) : C_2)$	Non-CCA	Prop. 2.9
	$k = 175$	$(C_3 \times C_3 \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 176$	$C_2 \times C_2 \times ((C_3 \times C_3) : C_4)$	Non-CCA	Prop. 2.9

$n=144$	$k=177$	$C_2\times((C_6\times C_6):C_2)$	Non-CCA	Prop. 2.9
	$k=178$	$C_{12}\times C_6\times C_2$	Non-CCA	Prop. 2.12
	$k=179$	$C_3\times C_6\times D_8$	Non-CCA	Prop. 2.9
	$k=180$	$C_3\times C_6\times Q_8$	Non-CCA	Prop. 2.9
	$k=181$	$C_3\times C_3\times((C_4\times C_2):C_2)$	Non-CCA	Prop. 2.9
	$k=182$	$((C_3\times C_3):C_8):C_2$	Non-CCA	Prop. 2.3
	$k=183$	$S_3\times S_4$	Non-CCA	Prop. 2.9
	$k=184$	$A_4\times A_4$	CCA	
	$k=185$	$C_2\times((C_3\times C_3):C_8)$	Non-CCA	Prop. 2.3
	$k=186$	$C_2\times((S_3\times S_3):C_2)$	Non-CCA	Prop. 2.9
	$k=187$	$C_2\times((C_3\times C_3):Q_8)$	Non-CCA	Prop. 2.9
	$k=188$	$C_6\times S_4$	Non-CCA	Prop. 2.9
	$k=189$	$C_2\times((C_3\times A_4):C_2)$	Non-CCA	Prop. 2.9
	$k=190$	$C_2\times A_4\times S_3$	CCA	
	$k=191$	$C_2\times C_2\times((C_3\times C_3):C_4)$	Non-CCA	Prop. 2.9
	$k=192$	$C_2\times C_2\times S_3\times S_3$	Non-CCA	Prop. 2.9
	$k=193$	$C_2\times C_6\times A_4$	CCA	
	$k=194$	$C_3\times((C_2\times C_2\times C_2\times C_2):C_3)$	CCA	
	$k=195$	$C_2\times C_2\times C_6\times S_3$	Non-CCA	Prop. 2.9
	$k=196$	$C_2\times C_2\times C_2\times((C_3\times C_3):C_2)$	CCA	Prop. 2.15
	$k=197$	$C_6\times C_6\times C_2\times C_2$	CCA	Prop. 2.12
$n=147$	$k=1$	$C_{49}:C_3$	CCA	
	$k=2$	C_{147}	CCA	Prop. 2.12
	$k=3$	$C_7\times(C_7:C_3)$	Non-CCA	Prop. 2.9
	$k=4$	$(C_7\times C_7):C_3$	CCA	
	$k=5$	$(C_7\times C_7):C_3$	CCA	
	$k=6$	$C_{21}\times C_7$	CCA	Prop. 2.12
$n=148$	$k=1$	$C_{37}:C_4$	Non-CCA	Cor. 2.4
	$k=2$	C_{148}	CCA	Prop. 2.12
	$k=3$	$C_{37}:C_4$	Non-CCA	Prop. 2.3
	$k=4$	D_{148}	CCA	Cor. 2.16
	$k=5$	$C_{74}\times C_2$	CCA	Prop. 2.12
$n=150$	$k=1$	$C_{25}\times S_3$	CCA	Prop. 2.10
	$k=2$	$C_3\times D_{50}$	CCA	Prop. 2.10
	$k=3$	D_{150}	CCA	Cor. 2.16
	$k=4$	C_{150}	CCA	Prop. 2.12
	$k=5$	$((C_5\times C_5):C_3):C_2$	CCA	
	$k=6$	$((C_5\times C_5):C_3):C_2$	CCA	
	$k=7$	$C_2\times((C_5\times C_5):C_3)$	CCA	Prop. 2.10

$n = 150$	$k = 8$	$C_{15} \times D_{10}$	Non-CCA	Prop. 2.9
	$k = 9$	$C_3 \times ((C_5 \times C_5) : C_2)$	CCA	Prop. 2.10
	$k = 10$	$C_5 \times C_5 \times S_3$	CCA	Prop. 2.10
	$k = 11$	$C_5 \times D_{30}$	Non-CCA	
	$k = 12$	$(C_{15} \times C_5) : C_2$	CCA	Prop. 2.15
	$k = 13$	$C_{30} \times C_5$	CCA	Prop. 2.12
$n = 152$	$k = 1$	$C_{19} : C_8$	CCA	
	$k = 2$	C_{152}	CCA	Prop. 2.12
	$k = 3$	$C_{19} : Q_8$	Non-CCA	Cor. 2.4
	$k = 4$	$C_4 \times D_{38}$	Non-CCA	Prop. 2.3
	$k = 5$	D_{152}	CCA	Cor. 2.16
	$k = 6$	$C_2 \times (C_{19} : C_4)$	Non-CCA	Prop. 2.9
	$k = 7$	$(C_{38} \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 8$	$C_{76} \times C_2$	Non-CCA	Prop. 2.12
	$k = 9$	$C_{19} \times D_8$	CCA	Prop. 2.10
	$k = 10$	$C_{19} \times Q_8$	Non-CCA	Prop. 2.9
	$k = 11$	$C_2 \times C_2 \times D_{38}$	CCA	Prop. 2.15
	$k = 12$	$C_{38} \times C_2 \times C_2$	CCA	Prop. 2.12
$n = 156$	$k = 1$	$(C_{13} : C_4) : C_3$	Non-CCA	Prop. 2.3
	$k = 2$	$C_4 \times (C_{13} : C_3)$	CCA	Prop. 2.10
	$k = 3$	$C_{13} \times (C_3 : C_4)$	Non-CCA	Prop. 2.9
	$k = 4$	$C_3 \times (C_{13} : C_4)$	Non-CCA	Prop. 2.9
	$k = 5$	$C_{39} : C_4$	Non-CCA	Cor. 2.4
	$k = 6$	C_{156}	CCA	Prop. 2.12
	$k = 7$	$(C_{13} : C_4) : C_3$	Non-CCA	Prop. 2.3
	$k = 8$	$C_2 \times ((C_{13} : C_3) : C_2)$	CCA	
	$k = 9$	$C_3 \times (C_{13} : C_4)$	Non-CCA	Prop. 2.9
	$k = 10$	$C_{39} : C_4$	Non-CCA	Prop. 2.3
	$k = 11$	$S_3 \times D_{26}$	CCA	
	$k = 12$	$C_2 \times C_2 \times (C_{13} : C_3)$	CCA	Prop. 2.10
	$k = 13$	$C_{13} \times A_4$	CCA	Prop. 2.10
	$k = 14$	$(C_{26} \times C_2) : C_3$	CCA	
	$k = 15$	$C_6 \times D_{26}$	CCA	Prop. 2.10
	$k = 16$	$C_{26} \times S_3$	CCA	Prop. 2.10
	$k = 17$	D_{156}	CCA	Cor. 2.16
	$k = 18$	$C_{78} \times C_2$	CCA	Prop. 2.12
$n = 160$	$k = 1$	$C_5 : C_{32}$	CCA	
	$k = 2$	C_{160}	CCA	Prop. 2.12
	$k = 3$	$C_5 : C_{32}$	Non-CCA	

	$k=4$	$C_{16} \times D_{10}$	Non-CCA	Prop. 2.3
	$k=5$	$C_{80} : C_2$	Non-CCA	Prop. 2.3
	$k=6$	D_{160}	CCA	Cor. 2.16
	$k=7$	$C_{80} : C_2$	Non-CCA	Prop. 2.3
	$k=8$	$C_5 : Q_{32}$	Non-CCA	Cor. 2.4
	$k=9$	$C_4 \times (C_5 : C_8)$	CCA	
	$k=10$	$(C_5 : C_8) : C_4$	CCA	
	$k=11$	$C_{20} : C_8$	CCA	
	$k=12$	$(C_{20} \times C_4) : C_2$	Non-CCA	Prop. 2.3
	$k=13$	$(C_5 \times ((C_4 \times C_2) : C_2)) : C_2$	Non-CCA	Prop. 2.3
	$k=14$	$(C_5 : C_8) : C_4$	Non-CCA	Prop. 2.3
	$k=15$	$(C_5 : C_8) : C_4$	Non-CCA	Prop. 2.3
	$k=16$	$(C_2 \times (C_5 : C_8)) : C_2$	Non-CCA	Prop. 2.3
	$k=17$	$(C_5 : Q_8) : C_4$	Non-CCA	Prop. 2.3
	$k=18$	$C_2 \times (C_5 : C_{16})$	CCA	
	$k=19$	$(C_5 : C_{16}) : C_2$	CCA	
	$k=20$	$C_8 \times (C_5 : C_4)$	Non-CCA	Prop. 2.9
	$k=21$	$(C_5 : C_4) : C_8$	Non-CCA	Prop. 2.3
	$k=22$	$C_{40} : C_4$	Non-CCA	Prop. 2.3
$n=160$	$k=23$	$(C_5 : Q_8) : C_4$	Non-CCA	Prop. 2.3
	$k=24$	$C_{40} : C_4$	Non-CCA	Prop. 2.3
	$k=25$	$C_{40} : C_4$	Non-CCA	Cor. 2.4
	$k=26$	$C_5 : (C_4.D_8)*$	CCA	
	$k=27$	$(C_{40} \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k=28$	$(C_{40} \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k=29$	$C_5 : (C_4.D_8)*$	CCA	
	$k=30$	$(C_5 \times (C_8 : C_2)) : C_2$	CCA	
	$k=31$	$C_5 : ((C_2 \times C_2).(C_4 \times C_2))*$	Non-CCA	Prop. 2.3
	$k=32$	$(C_5 \times (C_8 : C_2)) : C_2$	Non-CCA	Prop. 2.3
	$k=33$	$(C_5 \times D_{16}) : C_2$	CCA	
	$k=34$	$(C_5 : C_{16}) : C_2$	Non-CCA	Prop. 2.3
	$k=35$	$(C_5 \times Q_{16}) : C_2$	Non-CCA	Prop. 2.3
	$k=36$	$C_5 : Q_{32}$	Non-CCA	Prop. 2.3
	$k=37$	$(C_2 \times (C_5 : C_8)) : C_2$	Non-CCA	Prop. 2.3
	$k=38$	$(C_{20} \times C_2) : C_4$	Non-CCA	Prop. 2.3
	$k=39$	$(C_2 \times (C_5 : C_8)) : C_2$	Non-CCA	Prop. 2.3
	$k=40$	$((C_5 : C_8) : C_2) : C_2$	CCA	
	$k=41$	$((C_2 \times (C_5 : C_4)) : C_2) : C_2$	Non-CCA	Prop. 2.3
	$k=42$	$(C_5 \times Q_8) : C_4$	Non-CCA	Prop. 2.3

	$k=43$	$C_5:((C_2\times C_2).(C_4\times C_2))*$	Non-CCA	Prop. 2.3
	$k=44$	$(C_4\times(C_5:C_4)):C_2$	Non-CCA	Prop. 2.3
	$k=45$	$C_5\times((C_4\times C_2):C_4)$	Non-CCA	Prop. 2.9
	$k=46$	$C_{40}\times C_4$	CCA	Prop. 2.12
	$k=47$	$C_5\times(C_8:C_4)$	CCA	Prop. 2.10
	$k=48$	$C_5\times((C_8\times C_2):C_2)$	Non-CCA	Prop. 2.9
	$k=49$	$C_5\times(((C_4\times C_2):C_2):C_2)$	Non-CCA	Prop. 2.9
	$k=50$	$C_5\times((C_8:C_2):C_2)$	CCA	Prop. 2.10
	$k=51$	$C_5\times((C_2\times C_2).(C_4\times C_2))*$	Non-CCA	Prop. 2.9
	$k=52$	$C_5\times((C_8\times C_2):C_2)$	Non-CCA	Prop. 2.9
	$k=53$	$C_5\times(Q_8:C_4)$	Non-CCA	Prop. 2.9
	$k=54$	$C_5\times((C_4\times C_4):C_2)$	Non-CCA	Prop. 2.9
	$k=55$	$C_5\times(C_4:C_8)$	CCA	Prop. 2.10
	$k=56$	$C_5\times(C_8:C_4)$	Non-CCA	Prop. 2.9
	$k=57$	$C_5\times(C_8:C_4)$	Non-CCA	Prop. 2.9
	$k=58$	$C_5\times(C_4.D_8)*$	CCA	Prop. 2.10
	$k=59$	$C_{80}\times C_2$	CCA	Prop. 2.12
	$k=60$	$C_5\times(C_{16}:C_2)$	CCA	Prop. 2.10
	$k=61$	$C_5\times D_{32}$	CCA	Prop. 2.10
$n=160$	$k=62$	$C_5\times QD_{32}$	Non-CCA	Prop. 2.9
	$k=63$	$C_5\times Q_{32}$	Non-CCA	Prop. 2.9
	$k=64$	$(C_5:C_{16}):C_2$	Non-CCA	Prop. 2.3
	$k=65$	$(C_5:C_{16}):C_2$	Non-CCA	Prop. 2.3
	$k=66$	$C_8\times(C_5:C_4)$	Non-CCA	Prop. 2.9
	$k=67$	$C_{40}:C_4$	Non-CCA	Prop. 2.3
	$k=68$	$C_{40}:C_4$	Non-CCA	Prop. 2.3
	$k=69$	$C_{40}:C_4$	Non-CCA	Prop. 2.3
	$k=70$	$C_5:(C_4.D_8)*$	Non-CCA	Prop. 2.3
	$k=71$	$C_5:(C_4.D_8)*$	Non-CCA	Prop. 2.3
	$k=72$	$C_2\times(C_5:C_{16})$	Non-CCA	Prop. 2.9
	$k=73$	$(C_5:C_{16}):C_2$	Non-CCA	
	$k=74$	$((C_2\times(C_5:C_4)):C_2):C_2$	Non-CCA	Prop. 2.3
	$k=75$	$C_4\times(C_5:C_8)$	Non-CCA	Prop. 2.9
	$k=76$	$C_{20}:C_8$	Non-CCA	Prop. 2.3
	$k=77$	$(C_5:C_8):C_4$	Non-CCA	Prop. 2.3
	$k=78$	$(C_2\times(C_5:C_8)):C_2$	Non-CCA	Prop. 2.3
	$k=79$	$(C_5:C_4):C_8$	Non-CCA	Prop. 2.3
	$k=80$	$C_5:((C_2\times C_2).(C_4\times C_2))*$	Non-CCA	Prop. 2.3
	$k=81$	$(C_{20}\times C_2):C_4$	Non-CCA	Prop. 2.3

$n=160$	$k=82$	$(C_{20}:C_4):C_2$	Non-CCA	Prop. 2.3
	$k=83$	$(C_4\times(C_5:C_4)):C_2$	Non-CCA	Prop. 2.3
	$k=84$	$(C_5\times Q_8):C_4$	Non-CCA	Prop. 2.3
	$k=85$	$(C_4\times(C_5:C_4)):C_2$	Non-CCA	Prop. 2.3
	$k=86$	$((C_2\times(C_5:C_4)):C_2):C_2$	Non-CCA	Prop. 2.3
	$k=87$	$(C_2\times(C_5:C_8)):C_2$	Non-CCA	Prop. 2.3
	$k=88$	$((C_5:C_8):C_2):C_2$	Non-CCA	Prop. 2.3
	$k=89$	$C_4\times(C_5:Q_8)$	Non-CCA	Prop. 2.9
	$k=90$	$C_{20}:Q_8$	Non-CCA	Cor. 2.4
	$k=91$	$C_5:((C_2\times C_2).(C_2\times C_2\times C_2))$	Non-CCA	Prop. 2.3
	$k=92$	$C_4\times C_4\times D_{10}$	Non-CCA	Prop. 2.9
	$k=93$	$(C_{20}\times C_4):C_2$	Non-CCA	Prop. 2.3
	$k=94$	$C_4\times D_{40}$	Non-CCA	Prop. 2.3
	$k=95$	$(C_{20}\times C_4):C_2$	CCA	Prop. 2.15
	$k=96$	$(C_{20}\times C_4):C_2$	Non-CCA	Prop. 2.3
	$k=97$	$(C_{20}\times C_4):C_2$	Non-CCA	Prop. 2.3
	$k=98$	$(C_4\times(C_5:C_4)):C_2$	Non-CCA	Prop. 2.3
	$k=99$	$(C_2\times(C_5:Q_8)):C_2$	Non-CCA	Prop. 2.3
	$k=100$	$(C_4\times(C_5:C_4)):C_2$	Non-CCA	Prop. 2.3
	$k=101$	$((C_4\times C_2):C_2)\times D_{10}$	Non-CCA	Prop. 2.9
	$k=102$	$(C_2\times C_4\times D_{10}):C_2$	Non-CCA	Prop. 2.3
	$k=103$	$(C_2\times C_2\times C_2\times D_{10}):C_2$	Non-CCA	Prop. 2.3
	$k=104$	$(C_2\times C_4\times D_{10}):C_2$	Non-CCA	Prop. 2.3
	$k=105$	$(C_2\times C_4\times D_{10}):C_2$	Non-CCA	Prop. 2.3
	$k=106$	$(C_2\times(C_5:Q_8)):C_2$	Non-CCA	Prop. 2.3
	$k=107$	$(C_2\times C_2\times(C_5:C_4)):C_2$	Non-CCA	Prop. 2.3
	$k=108$	$(C_5:Q_8):C_4$	Non-CCA	Prop. 2.3
	$k=109$	$C_{20}:Q_8$	Non-CCA	Prop. 2.3
	$k=110$	$C_5:((C_2\times C_2).(C_2\times C_2\times C_2))$	Non-CCA	Prop. 2.3
	$k=111$	$C_5:((C_2\times C_2).(C_2\times C_2\times C_2))$	Non-CCA	Prop. 2.3
	$k=112$	$(C_4:C_4)\times D_{10}$	Non-CCA	Prop. 2.9
	$k=113$	$(C_4\times(C_5:C_4)):C_2$	Non-CCA	Prop. 2.3
	$k=114$	$(C_2\times C_4\times D_{10}):C_2$	Non-CCA	Prop. 2.3
	$k=115$	$(C_2\times C_4\times D_{10}):C_2$	Non-CCA	Prop. 2.3
	$k=116$	$(C_2\times C_4\times D_{10}):C_2$	Non-CCA	Prop. 2.3
	$k=117$	$(C_2\times(C_5:Q_8)):C_2$	Non-CCA	Prop. 2.3
	$k=118$	$(C_5\times(C_4:C_4)):C_2$	Non-CCA	Prop. 2.3
	$k=119$	$(C_5\times(C_4:C_4)):C_2$	Non-CCA	Prop. 2.3
	$k=120$	$C_2\times C_8\times D_{10}$	Non-CCA	Prop. 2.9

$n = 160$	$k = 121$	$C_2 \times (C_{40} : C_2)$	Non-CCA	Prop. 2.9
	$k = 122$	$(C_{40} \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 123$	$C_2 \times (C_{40} : C_2)$	Non-CCA	Prop. 2.9
	$k = 124$	$C_2 \times D_{80}$	CCA	Prop. 2.15
	$k = 125$	$(C_{40} \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 126$	$C_2 \times (C_5 : Q_{16})$	Non-CCA	Prop. 2.9
	$k = 127$	$(C_8 : C_2) \times D_{10}$	Non-CCA	Prop. 2.3
	$k = 128$	$(C_8 \times D_{10}) : C_2$	Non-CCA	Prop. 2.3
	$k = 129$	$(C_2 \times D_{40}) : C_2$	Non-CCA	Prop. 2.3
	$k = 130$	$(C_5 \times (C_8 : C_2)) : C_2$	Non-CCA	Prop. 2.3
	$k = 131$	$D_{16} \times D_{10}$	Non-CCA	Prop. 2.3
	$k = 132$	$(D_8 \times D_{10}) : C_2$	Non-CCA	Prop. 2.3
	$k = 133$	$(C_8 \times D_{10}) : C_2$	Non-CCA	Prop. 2.3
	$k = 134$	$QD_{16} \times D_{10}$	Non-CCA	Prop. 2.9
	$k = 135$	$(D_8 \times D_{10}) : C_2$	Non-CCA	Prop. 2.3
	$k = 136$	$(Q_8 \times D_{10}) : C_2$	Non-CCA	Prop. 2.3
	$k = 137$	$(C_8 \times D_{10}) : C_2$	Non-CCA	Prop. 2.3
	$k = 138$	$Q_{16} \times D_{10}$	Non-CCA	Prop. 2.9
	$k = 139$	$(C_5 \times Q_{16}) : C_2$	Non-CCA	Prop. 2.3
	$k = 140$	$(C_8 \times D_{10}) : C_2$	Non-CCA	Prop. 2.3
	$k = 141$	$C_2 \times C_2 \times (C_5 : C_8)$	Non-CCA	Prop. 2.3
	$k = 142$	$C_2 \times ((C_5 : C_8) : C_2)$	Non-CCA	Prop. 2.3
	$k = 143$	$C_2 \times C_4 \times (C_5 : C_4)$	Non-CCA	Prop. 2.9
	$k = 144$	$C_2 \times ((C_5 : C_4) : C_4)$	Non-CCA	Prop. 2.9
	$k = 145$	$(C_2 \times (C_5 : Q_8)) : C_2$	Non-CCA	Prop. 2.3
	$k = 146$	$C_2 \times (C_{20} : C_4)$	Non-CCA	Prop. 2.9
	$k = 147$	$(C_4 \times (C_5 : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k = 148$	$C_2 \times ((C_{20} \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 149$	$C_4 \times ((C_{10} \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 150$	$(C_{20} \times C_2 \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 151$	$(C_{20} \times C_2 \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 152$	$C_2 \times ((C_5 \times D_8) : C_2)$	CCA	
	$k = 153$	$(C_{10} \times D_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 154$	$C_2 \times ((C_5 : C_8) : C_2)$	Non-CCA	Prop. 2.3
	$k = 155$	$D_8 \times (C_5 : C_4)$	Non-CCA	Prop. 2.9
	$k = 156$	$(C_2 \times C_2 \times (C_5 : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k = 157$	$(C_2 \times (C_5 : Q_8)) : C_2$	Non-CCA	Prop. 2.3
	$k = 158$	$(C_2 \times C_2 \times C_2 \times D_{10}) : C_2$	Non-CCA	Prop. 2.3
	$k = 159$	$(C_{10} \times D_8) : C_2$	Non-CCA	Prop. 2.3

$n = 160$	$k = 160$	$(C_2 \times C_2 \times (C_5 : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k = 161$	$(C_{10} \times D_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 162$	$C_2 \times ((C_5 \times Q_8) : C_2)$	Non-CCA	Prop. 2.9
	$k = 163$	$(C_{10} \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 164$	$C_2 \times (C_5 : Q_{16})$	Non-CCA	Prop. 2.9
	$k = 165$	$(C_5 : C_4) : Q_8$	Non-CCA	Prop. 2.3
	$k = 166$	$Q_8 \times (C_5 : C_4)$	Non-CCA	Prop. 2.9
	$k = 167$	$(C_{10} \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 168$	$(C_{10} \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 169$	$(C_2 \times (C_5 : C_8)) : C_2$	Non-CCA	Prop. 2.3
	$k = 170$	$(C_2 \times D_{40}) : C_2$	Non-CCA	Prop. 2.3
	$k = 171$	$(C_2 \times (C_5 : C_8)) : C_2$	Non-CCA	Prop. 2.3
	$k = 172$	$(C_2 \times (C_5 : Q_8)) : C_2$	Non-CCA	Prop. 2.3
	$k = 173$	$C_2 \times ((C_2 \times (C_5 : C_4)) : C_2)$	Non-CCA	Prop. 2.9
	$k = 174$	$(C_{10} \times C_2 \times C_2 \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 175$	$C_{20} \times C_4 \times C_2$	Non-CCA	Prop. 2.12
	$k = 176$	$C_{10} \times ((C_4 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 177$	$C_{10} \times (C_4 : C_4)$	Non-CCA	Prop. 2.9
	$k = 178$	$C_5 \times ((C_4 \times C_4) : C_2)$	Non-CCA	Prop. 2.9
	$k = 179$	$C_{20} \times D_8$	Non-CCA	Prop. 2.9
	$k = 180$	$C_{20} \times Q_8$	Non-CCA	Prop. 2.9
	$k = 181$	$C_5 \times ((C_2 \times C_2 \times C_2 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 182$	$C_5 \times ((C_4 \times C_2 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 183$	$C_5 \times ((C_2 \times Q_8) : C_2)$	Non-CCA	Prop. 2.9
	$k = 184$	$C_5 \times ((C_4 \times C_2 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 185$	$C_5 \times ((C_4 \times C_4) : C_2)$	Non-CCA	Prop. 2.9
	$k = 186$	$C_5 \times ((C_2 \times C_2).(C_2 \times C_2 \times C_2))$	Non-CCA	Prop. 2.9
	$k = 187$	$C_5 \times ((C_4 \times C_4) : C_2)$	Non-CCA	Prop. 2.9
	$k = 188$	$C_5 \times ((C_4 \times C_4) : C_2)$	CCA	Prop. 2.10
	$k = 189$	$C_5 \times (C_4 : Q_8)$	Non-CCA	Prop. 2.9
	$k = 190$	$C_{40} \times C_2 \times C_2$	Non-CCA	Prop. 2.12
	$k = 191$	$C_{10} \times (C_8 : C_2)$	Non-CCA	Prop. 2.9
	$k = 192$	$C_5 \times ((C_8 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 193$	$C_{10} \times D_{16}$	CCA	Prop. 2.10
	$k = 194$	$C_{10} \times QD_{16}$	Non-CCA	Prop. 2.9
	$k = 195$	$C_{10} \times Q_{16}$	Non-CCA	Prop. 2.9
	$k = 196$	$C_5 \times ((C_8 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 197$	$C_5 \times ((C_2 \times D_8) : C_2)$	Non-CCA	Prop. 2.9
	$k = 198$	$C_5 \times ((C_2 \times Q_8) : C_2)$	Non-CCA	Prop. 2.9

$n = 160$	$k = 199$	$((C_2 \times Q_8) : C_2) : C_5$	Non-CCA	Prop. 2.3
	$k = 200$	$C_2 \times ((C_5 : C_8) : C_2)$	Non-CCA	Prop. 2.3
	$k = 201$	$C_2 \times ((C_5 : C_8) : C_2)$	Non-CCA	Prop. 2.3
	$k = 202$	$((C_5 : C_8) : C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 203$	$C_2 \times C_4 \times (C_5 : C_4)$	Non-CCA	Prop. 2.9
	$k = 204$	$C_2 \times (C_{20} : C_4)$	Non-CCA	Prop. 2.9
	$k = 205$	$(C_4 \times (C_5 : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k = 206$	$(C_2 \times (C_5 : C_8)) : C_2$	Non-CCA	Prop. 2.3
	$k = 207$	$D_8 \times (C_5 : C_4)$	Non-CCA	Prop. 2.9
	$k = 208$	$((C_5 : C_8) : C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 209$	$Q_8 \times (C_5 : C_4)$	Non-CCA	Prop. 2.9
	$k = 210$	$C_2 \times C_2 \times (C_5 : C_8)$	Non-CCA	Prop. 2.3
	$k = 211$	$C_2 \times ((C_5 : C_8) : C_2)$	Non-CCA	Prop. 2.3
	$k = 212$	$C_2 \times ((C_2 \times (C_5 : C_4)) : C_2)$	Non-CCA	Prop. 2.9
	$k = 213$	$C_2 \times C_2 \times (C_5 : Q_8)$	Non-CCA	Prop. 2.9
	$k = 214$	$C_2 \times C_2 \times C_4 \times D_{10}$	Non-CCA	Prop. 2.9
	$k = 215$	$C_2 \times C_2 \times D_{40}$	Non-CCA	Prop. 2.9
	$k = 216$	$C_2 \times ((C_{20} \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 217$	$C_2 \times D_8 \times D_{10}$	Non-CCA	Prop. 2.9
	$k = 218$	$C_2 \times ((C_2 \times (C_5 : C_4)) : C_2)$	Non-CCA	Prop. 2.9
	$k = 219$	$(C_{10} \times D_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 220$	$C_2 \times Q_8 \times D_{10}$	Non-CCA	Prop. 2.9
	$k = 221$	$C_2 \times ((C_4 \times D_{10}) : C_2)$	Non-CCA	Prop. 2.9
	$k = 222$	$(C_{10} \times Q_8) : C_2$	Non-CCA	Prop. 2.3
	$k = 223$	$((C_4 \times C_2) : C_2) \times D_{10}$	Non-CCA	Prop. 2.9
	$k = 224$	$(D_8 \times D_{10}) : C_2$	Non-CCA	Prop. 2.3
	$k = 225$	$(Q_8 \times D_{10}) : C_2$	Non-CCA	Prop. 2.3
	$k = 226$	$C_2 \times C_2 \times C_2 \times (C_5 : C_4)$	Non-CCA	Prop. 2.9
	$k = 227$	$C_2 \times C_2 \times ((C_{10} \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 228$	$C_{20} \times C_2 \times C_2 \times C_2$	Non-CCA	Prop. 2.12
	$k = 229$	$C_2 \times C_{10} \times D_8$	Non-CCA	Prop. 2.9
	$k = 230$	$C_2 \times C_{10} \times Q_8$	Non-CCA	Prop. 2.9
	$k = 231$	$C_{10} \times ((C_4 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 232$	$C_5 \times ((C_2 \times D_8) : C_2)$	Non-CCA	Prop. 2.9
	$k = 233$	$C_5 \times ((C_2 \times Q_8) : C_2)$	Non-CCA	Prop. 2.9
	$k = 234$	$((C_2 \times C_2 \times C_2 \times C_2) : C_5) : C_2$	Non-CCA	Prop. 2.3
	$k = 235$	$C_2 \times ((C_2 \times C_2 \times C_2 \times C_2) : C_5)$	CCA	
	$k = 236$	$C_2 \times C_2 \times C_2 \times (C_5 : C_4)$	Non-CCA	Prop. 2.9
	$k = 237$	$C_2 \times C_2 \times C_2 \times C_2 \times D_{10}$	CCA$\sim$	Prop. 2.15

$n = 160$	$k = 238$	$C_{10} \times C_2 \times C_2 \times C_2 \times C_2$	CCA	Prop. 2.12
	$k = 1$	D_{162}	CCA	Cor. 2.16
	$k = 2$	C_{162}	CCA	Prop. 2.12
	$k = 3$	$C_9 \times D_{18}$	Non-CCA	
	$k = 4$	$((C_9 \times C_3) : C_3) : C_2$	CCA	
	$k = 5$	$((C_9 \times C_3) : C_3) : C_2$	CCA	
	$k = 6$	$(C_9 : C_9) : C_2$	CCA	
	$k = 7$	$C_3 \times D_{54}$	CCA	
	$k = 8$	$C_{27} \times S_3$	CCA	
	$k = 9$	$(C_{27} : C_3) : C_2$	CCA	
	$k = 10$	$((C_3 \times C_3 \times C_3) : C_3) : C_2$	Non-CCA	
	$k = 11$	$((C_3 \times C_3 \times C_3) : C_3) : C_2$	Non-CCA	
	$k = 12$	$((C_9 \times C_3) : C_3) : C_2$	CCA	
	$k = 13$	$((C_9 \times C_3) : C_3) : C_2$	CCA	
	$k = 14$	$((C_9 \times C_3) : C_3) : C_2$	CCA	
	$k = 15$	$((C_9 \times C_3) : C_3) : C_2$	CCA	
	$k = 16$	$(C_9 \times C_9) : C_2$	CCA	Prop. 2.15
	$k = 17$	$((C_9 \times C_3) : C_3) : C_2$	CCA	
	$k = 18$	$(C_{27} \times C_3) : C_2$	CCA	Prop. 2.15
$n = 162$	$k = 19$	$((C_3 \times C_3 \times C_3) : C_3) : C_2$	Non-CCA	
	$k = 20$	$((C_9 \times C_3) : C_3) : C_2$	CCA	
	$k = 21$	$((C_9 \times C_3) : C_3) : C_2$	CCA	
	$k = 22$	$(C_3.((C_3 \times C_3) : C_3)) : C_2*$	CCA	
	$k = 23$	$C_{18} \times C_9$	CCA	Prop. 2.12
	$k = 24$	$C_2 \times ((C_9 \times C_3) : C_3)$	CCA	Prop. 2.10
	$k = 25$	$C_2 \times (C_9 : C_9)$	CCA	Prop. 2.10
	$k = 26$	$C_{54} \times C_3$	CCA	Prop. 2.12
	$k = 27$	$C_2 \times (C_{27} : C_3)$	CCA	Prop. 2.10
	$k = 28$	$C_2 \times ((C_3 \times C_3 \times C_3) : C_3)$	Non-CCA	Prop. 2.9
	$k = 29$	$C_2 \times ((C_9 \times C_3) : C_3)$	CCA	Prop. 2.10
	$k = 30$	$C_2 \times ((C_9 \times C_3) : C_3)$	CCA	Prop. 2.10
	$k = 31$	$C_2 \times ((C_3 \times C_3).(C_3 \times C_3))*$	CCA	Prop. 2.10
	$k = 32$	$C_3 \times C_3 \times D_{18}$	CCA	
	$k = 33$	$C_3 \times C_9 \times S_3$	Non-CCA	Prop. 2.9
	$k = 34$	$C_3 \times (((C_3 \times C_3) : C_3) : C_2)$	Non-CCA	Prop. 2.9
	$k = 35$	$((C_3 \times C_3) : C_3) \times S_3$	CCA	
	$k = 36$	$C_3 \times ((C_9 : C_3) : C_2)$	CCA	
	$k = 37$	$(C_9 : C_3) \times S_3$	CCA	
	$k = 38$	$C_3 \times ((C_9 \times C_3) : C_2)$	Non-CCA	

	$k = 39$	$C_9 \times ((C_3 \times C_3) : C_2)$	CCA	
	$k = 40$	$(C_3 \times ((C_3 \times C_3) : C_3)) : C_2$	Non-CCA	
	$k = 41$	$C_3 \times (((C_3 \times C_3) : C_3) : C_2)$	CCA	
	$k = 42$	$(C_3 \times (C_9 : C_3)) : C_2$	CCA	
	$k = 43$	$((C_9 \times C_3) : C_3) : C_2$	Non-CCA	
	$k = 44$	$((C_9 \times C_3) : C_3) : C_2$	CCA	
	$k = 45$	$(C_9 \times C_3 \times C_3) : C_2$	CCA	Prop. 2.15
	$k = 46$	$(C_3 \times ((C_3 \times C_3) : C_3)) : C_2$	CCA	
$n = 162$	$k = 47$	$C_{18} \times C_3 \times C_3$	CCA	Prop. 2.12
	$k = 48$	$C_6 \times ((C_3 \times C_3) : C_3)$	CCA	Prop. 2.10
	$k = 49$	$C_6 \times (C_9 : C_3)$	CCA	Prop. 2.10
	$k = 50$	$C_2 \times ((C_9 \times C_3) : C_3)$	CCA	Prop. 2.10
	$k = 51$	$C_3 \times C_3 \times C_3 \times S_3$	Non-CCA	Prop. 2.9
	$k = 52$	$C_3 \times C_3 \times ((C_3 \times C_3) : C_2)$	Non-CCA	Prop. 2.9
	$k = 53$	$C_3 \times ((C_3 \times C_3 \times C_3) : C_2)$	Non-CCA	
	$k = 54$	$(C_3 \times C_3 \times C_3 \times C_3) : C_2$	CCA	Prop. 2.15
	$k = 55$	$C_6 \times C_3 \times C_3 \times C_3$	CCA	Prop. 2.12
	$k = 1$	$C_{41} : C_4$	Non-CCA	Cor. 2.4
	$k = 2$	C_{164}	CCA	Prop. 2.12
$n = 164$	$k = 3$	$C_{41} : C_4$	Non-CCA	Prop. 2.3
	$k = 4$	D_{164}	CCA	Cor. 2.16
	$k = 5$	$C_{82} \times C_2$	CCA	Prop. 2.12
	$k = 1$	$(C_7 : C_8) : C_3$	Non-CCA	
	$k = 2$	$C_8 \times (C_7 : C_3)$	Non-CCA	Prop. 2.9
	$k = 3$	$C_7 \times (C_3 : C_8)$	CCA	Prop. 2.10
	$k = 4$	$C_3 \times (C_7 : C_8)$	CCA	Prop. 2.10
	$k = 5$	$C_{21} : C_8$	CCA	
	$k = 6$	C_{168}	CCA	Prop. 2.12
	$k = 7$	$(C_7 : Q_8) : C_3$	Non-CCA	Prop. 2.3
	$k = 8$	$C_4 \times ((C_7 : C_3) : C_2)$	Non-CCA	Prop. 2.9
$n = 168$	$k = 9$	$(C_2 \times ((C_7 : C_3) : C_2)) : C_2$	Non-CCA	
	$k = 10$	$C_2 \times ((C_7 : C_4) : C_3)$	Non-CCA	Prop. 2.9
	$k = 11$	$(C_2 \times C_2 \times (C_7 : C_3)) : C_2$	Non-CCA	Prop. 2.3
	$k = 12$	$(C_3 : C_4) \times D_{14}$	Non-CCA	Prop. 2.9
	$k = 13$	$S_3 \times (C_7 : C_4)$	Non-CCA	Prop. 2.9
	$k = 14$	$(C_7 \times (C_3 : C_4)) : C_2$	Non-CCA	Prop. 2.3
	$k = 15$	$(C_{14} \times S_3) : C_2$	Non-CCA	Prop. 2.3
	$k = 16$	$(C_6 \times D_{14}) : C_2$	Non-CCA	Prop. 2.3
	$k = 17$	$(C_{14} \times S_3) : C_2$	Non-CCA	Prop. 2.3

	$k=18$	$C_{21}:Q_8$	Non-CCA	Prop. 2.3
	$k=19$	$C_2\times C_4\times(C_7:C_3)$	Non-CCA	Prop. 2.9
	$k=20$	$D_8\times(C_7:C_3)$	Non-CCA	Prop. 2.9
	$k=21$	$Q_8\times(C_7:C_3)$	Non-CCA	Prop. 2.9
	$k=22$	$C_7\times SL(2,3)$	Non-CCA	Prop. 2.9
	$k=23$	$(C_7\times Q_8):C_3$	Non-CCA	Prop. 2.3
	$k=24$	$C_3\times(C_7:Q_8)$	Non-CCA	Prop. 2.9
	$k=25$	$C_{12}\times D_{14}$	Non-CCA	Prop. 2.9
	$k=26$	$C_3\times D_{56}$	CCA	Prop. 2.10
	$k=27$	$C_6\times(C_7:C_4)$	Non-CCA	Prop. 2.9
	$k=28$	$C_3\times((C_{14}\times C_2):C_2)$	Non-CCA	Prop. 2.9
	$k=29$	$C_7\times(C_3:Q_8)$	Non-CCA	Prop. 2.9
	$k=30$	$C_{28}\times S_3$	Non-CCA	Prop. 2.9
	$k=31$	$C_7\times D_{24}$	CCA	Prop. 2.10
	$k=32$	$C_{14}\times(C_3:C_4)$	Non-CCA	Prop. 2.9
	$k=33$	$C_7\times((C_6\times C_2):C_2)$	Non-CCA	Prop. 2.9
	$k=34$	$C_{21}:Q_8$	Non-CCA	Cor. 2.4
	$k=35$	$C_4\times D_{42}$	Non-CCA	Prop. 2.3
	$k=36$	D_{168}	CCA	Cor. 2.16
$n=168$	$k=37$	$C_2\times(C_{21}:C_4)$	Non-CCA	Prop. 2.9
	$k=38$	$(C_{42}\times C_2):C_2$	Non-CCA	Prop. 2.3
	$k=39$	$C_{84}\times C_2$	Non-CCA	Prop. 2.12
	$k=40$	$C_{21}\times D_8$	CCA	Prop. 2.10
	$k=41$	$C_{21}\times Q_8$	Non-CCA	Prop. 2.9
	$k=42$	$PSL(3,2)$	Non-CCA	Prop. 2.3
	$k=43$	$((C_2\times C_2\times C_2):C_7):C_3$	Non-CCA	
	$k=44$	$C_3\times((C_2\times C_2\times C_2):C_7)$	CCA	Prop. 2.10
	$k=45$	$C_7\times S_4$	Non-CCA	Prop. 2.9
	$k=46$	$(C_7\times A_4):C_2$	Non-CCA	Prop. 2.3
	$k=47$	$C_2\times C_2\times((C_7:C_3):C_2)$	Non-CCA	Prop. 2.9
	$k=48$	$A_4\times D_{14}$	CCA	
	$k=49$	$((C_{14}\times C_2):C_3):C_2$	CCA	
	$k=50$	$C_2\times S_3\times D_{14}$	CCA	
	$k=51$	$C_2\times C_2\times C_2\times(C_7:C_3)$	Non-CCA	Prop. 2.9
	$k=52$	$C_{14}\times A_4$	CCA	Prop. 2.10
	$k=53$	$C_2\times((C_{14}\times C_2):C_3)$	CCA	
	$k=54$	$C_2\times C_6\times D_{14}$	CCA	Prop. 2.10
	$k=55$	$C_2\times C_{14}\times S_3$	CCA$\sim$	Prop. 2.10
	$k=56$	$C_2\times C_2\times D_{42}$	CCA	Prop. 2.15

$n=168$	$k=57$	$C_{42}\times C_2\times C_2$	CCA	Prop. 2.12
$n=172$	$k=1$	$C_{43}:C_4$	Non-CCA	Cor. 2.4
	$k=2$	C_{172}	CCA	Prop. 2.12
	$k=3$	D_{172}	CCA	Cor. 2.16
	$k=4$	$C_{86}\times C_2$	CCA	Prop. 2.12
$n=176$	$k=1$	$C_{11}:C_{16}$	CCA	
	$k=2$	C_{176}	CCA	Prop. 2.12
	$k=3$	$C_8\times D_{22}$	Non-CCA	Prop. 2.3
	$k=4$	$C_{88}:C_2$	Non-CCA	Prop. 2.3
	$k=5$	$C_{88}:C_2$	Non-CCA	Prop. 2.3
	$k=6$	D_{176}	CCA	Cor. 2.16
	$k=7$	$C_{11}:Q_{16}$	Non-CCA	Cor. 2.4
	$k=8$	$C_2\times(C_{11}:C_8)$	CCA	
	$k=9$	$(C_{11}:C_8):C_2$	CCA	
	$k=10$	$C_4\times(C_{11}:C_4)$	Non-CCA	Prop. 2.9
	$k=11$	$(C_{11}:C_4):C_4$	Non-CCA	Prop. 2.3
	$k=12$	$C_{44}:C_4$	Non-CCA	Cor. 2.4
	$k=13$	$(C_{44}\times C_2):C_2$	Non-CCA	Prop. 2.3
	$k=14$	$(C_{11}\times D_8):C_2$	CCA	
	$k=15$	$(C_{11}:C_8):C_2$	Non-CCA	Prop. 2.3
	$k=16$	$(C_{11}\times Q_8):C_2$	Non-CCA	Prop. 2.3
	$k=17$	$C_{11}:Q_{16}$	Non-CCA	Prop. 2.3
	$k=18$	$(C_2\times(C_{11}:C_4)):C_2$	Non-CCA	Prop. 2.3
	$k=19$	$C_{44}\times C_4$	CCA	Prop. 2.12
	$k=20$	$C_{11}\times((C_4\times C_2):C_2)$	Non-CCA	Prop. 2.9
	$k=21$	$C_{11}\times(C_4:C_4)$	Non-CCA	Prop. 2.9
	$k=22$	$C_{88}\times C_2$	CCA	Prop. 2.12
	$k=23$	$C_{11}\times(C_8:C_2)$	CCA	Prop. 2.10
	$k=24$	$C_{11}\times D_{16}$	CCA	Prop. 2.10
	$k=25$	$C_{11}\times QD_{16}$	Non-CCA	Prop. 2.9
	$k=26$	$C_{11}\times Q_{16}$	Non-CCA	Prop. 2.9
	$k=27$	$C_2\times(C_{11}:Q_8)$	Non-CCA	Prop. 2.9
	$k=28$	$C_2\times C_4\times D_{22}$	Non-CCA	Prop. 2.9
	$k=29$	$C_2\times D_{88}$	Non-CCA	Prop. 2.15
	$k=30$	$(C_{44}\times C_2):C_2$	Non-CCA	Prop. 2.3
	$k=31$	$D_8\times D_{22}$	Non-CCA	Prop. 2.3
	$k=32$	$(C_2\times(C_{11}:C_4)):C_2$	Non-CCA	Prop. 2.3
	$k=33$	$Q_8\times D_{22}$	Non-CCA	Prop. 2.9
	$k=34$	$(C_4\times D_{22}):C_2$	Non-CCA	Prop. 2.3

$n = 176$	$k = 35$	$C_2 \times C_2 \times (C_{11} : C_4)$	Non-CCA	Prop. 2.9
	$k = 36$	$C_2 \times ((C_{22} \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 37$	$C_{44} \times C_2 \times C_2$	Non-CCA	Prop. 2.12
	$k = 38$	$C_{22} \times D_8$	Non-CCA	Prop. 2.9
	$k = 39$	$C_{22} \times Q_8$	Non-CCA	Prop. 2.9
	$k = 40$	$C_{11} \times ((C_4 \times C_2) : C_2)$	Non-CCA	Prop. 2.9
	$k = 41$	$C_2 \times C_2 \times C_2 \times D_{22}$	CCA	Prop. 2.15
	$k = 42$	$C_{22} \times C_2 \times C_2 \times C_2$	CCA	Prop. 2.12
$n = 180$	$k = 1$	$C_5 \times (C_9 : C_4)$	Non-CCA	Prop. 2.9
	$k = 2$	$C_9 \times (C_5 : C_4)$	Non-CCA	Prop. 2.9
	$k = 3$	$C_{45} : C_4$	Non-CCA	Cor. 2.4
	$k = 4$	C_{180}	CCA	Prop. 2.12
	$k = 5$	$C_9 \times (C_5 : C_4)$	Non-CCA	Prop. 2.9
	$k = 6$	$C_{45} : C_4$	Non-CCA	Prop. 2.3
	$k = 7$	$D_{10} \times D_{18}$	CCA	
	$k = 8$	$C_5 \times ((C_2 \times C_2) : C_9)$	CCA	Prop. 2.10
	$k = 9$	$C_{18} \times D_{10}$	CCA	Prop. 2.10
	$k = 10$	$C_{10} \times D_{18}$	CCA$\sim$	Prop. 2.10
	$k = 11$	D_{180}	CCA	Cor. 2.16
	$k = 12$	$C_{90} \times C_2$	CCA	Prop. 2.12
	$k = 13$	$C_3 \times C_3 \times (C_5 : C_4)$	Non-CCA	Prop. 2.9
	$k = 14$	$C_{15} \times (C_3 : C_4)$	Non-CCA	Prop. 2.9
	$k = 15$	$C_3 \times (C_{15} : C_4)$	Non-CCA	Prop. 2.9
	$k = 16$	$C_5 \times ((C_3 \times C_3) : C_4)$	Non-CCA	Prop. 2.9
	$k = 17$	$(C_{15} \times C_3) : C_4$	Non-CCA	Cor. 2.4
	$k = 18$	$C_{60} \times C_3$	CCA	Prop. 2.12
	$k = 19$	$GL(2,4)$	CCA	
	$k = 20$	$C_3 \times C_3 \times (C_5 : C_4)$	Non-CCA	Prop. 2.9
	$k = 21$	$C_3 \times (C_{15} : C_4)$	Non-CCA	Prop. 2.9
	$k = 22$	$(C_{15} \times C_3) : C_4$	Non-CCA	Prop. 2.3
	$k = 23$	$C_5 \times ((C_3 \times C_3) : C_4)$	Non-CCA	Prop. 2.9
	$k = 24$	$(C_{15} \times C_3) : C_4$	Non-CCA	Prop. 2.3
	$k = 25$	$(C_{15} \times C_3) : C_4$	Non-CCA	Prop. 2.3
	$k = 26$	$C_3 \times S_3 \times D_{10}$	Non-CCA	Prop. 2.9
	$k = 27$	$((C_3 \times C_3) : C_2) \times D_{10}$	CCA	
	$k = 28$	$C_5 \times S_3 \times S_3$	Non-CCA	Prop. 2.9
	$k = 29$	$S_3 \times D_{30}$	Non-CCA	
	$k = 30$	$(C_5 \times ((C_3 \times C_3) : C_2)) : C_2$	Non-CCA	
	$k = 31$	$C_{15} \times A_4$	CCA$\sim$	Prop. 2.10

$n = 180$	$k = 32$	$C_3 \times C_6 \times D_{10}$	CCA	Prop. 2.10
	$k = 33$	$C_{30} \times S_3$	Non-CCA	Prop. 2.9
	$k = 34$	$C_6 \times D_{30}$	Non-CCA	Prop. 2.9
	$k = 35$	$C_{10} \times ((C_3 \times C_3) : C_2)$	CCA	
	$k = 36$	$C_2 \times ((C_{15} \times C_3) : C_2)$	CCA	Prop. 2.15
	$k = 37$	$C_{30} \times C_6$	CCA	Prop. 2.12
$n = 184$	$k = 1$	$C_{23} : C_8$	CCA	
	$k = 2$	C_{184}	CCA	Prop. 2.12
	$k = 3$	$C_{23} : Q_8$	Non-CCA	Cor. 2.4
	$k = 4$	$C_4 \times D_{46}$	Non-CCA	Prop. 2.3
	$k = 5$	D_{184}	CCA	Cor. 2.16
	$k = 6$	$C_2 \times (C_{23} : C_4)$	Non-CCA	Prop. 2.9
	$k = 7$	$(C_{46} \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 8$	$C_{92} \times C_2$	Non-CCA	Prop. 2.12
	$k = 9$	$C_{23} \times D_8$	CCA	Prop. 2.10
	$k = 10$	$C_{23} \times Q_8$	Non-CCA	Prop. 2.9
	$k = 11$	$C_2 \times C_2 \times D_{46}$	CCA	Prop. 2.15
	$k = 12$	$C_{46} \times C_2 \times C_2$	CCA	Prop. 2.12
$n = 188$	$k = 1$	$C_{47} : C_4$	Non-CCA	Cor. 2.4
	$k = 2$	C_{188}	CCA	Prop. 2.12
	$k = 3$	D_{188}	CCA	Cor. 2.16
	$k = 4$	$C_{94} \times C_2$	CCA	Prop. 2.12
$n = 189$	$k = 1$	$C_7 : C_{27}$	CCA	
	$k = 2$	C_{189}	CCA	Prop. 2.12
	$k = 3$	$C_9 \times (C_7 : C_3)$	Non-CCA	Prop. 2.9
	$k = 4$	$C_{63} : C_3$	CCA	
	$k = 5$	$C_{63} : C_3$	CCA	
	$k = 6$	$C_3 \times (C_7 : C_9)$	CCA	
	$k = 7$	$(C_7 : C_9) : C_3$	CCA	
	$k = 8$	$(C_{21} \times C_3) : C_3$	CCA	
	$k = 9$	$C_{63} \times C_3$	CCA	Prop. 2.12
	$k = 10$	$C_7 \times ((C_3 \times C_3) : C_3)$	CCA	Prop. 2.10
	$k = 11$	$C_7 \times (C_9 : C_3)$	CCA	Prop. 2.10
	$k = 12$	$C_3 \times C_3 \times (C_7 : C_3)$	Non-CCA	Prop. 2.9
	$k = 13$	$C_{21} \times C_3 \times C_3$	CCA	Prop. 2.12
$n = 196$	$k = 1$	$C_{49} : C_4$	Non-CCA	Cor. 2.4
	$k = 2$	C_{196}	CCA	Prop. 2.12
	$k = 3$	D_{196}	CCA	Cor. 2.16
	$k = 4$	$C_{98} \times C_2$	CCA	Prop. 2.12

$n = 196$	$k = 5$	$C_7 \times (C_7 : C_4)$	Non-CCA	Prop. 2.9
	$k = 6$	$(C_7 \times C_7) : C_4$	Non-CCA	Cor. 2.4
	$k = 7$	$C_{28} \times C_7$	CCA	Prop. 2.12
	$k = 8$	$(C_7 \times C_7) : C_4$	Non-CCA	Prop. 2.3
	$k = 9$	$D_{14} \times D_{14}$	Non-CCA	
	$k = 10$	$C_{14} \times D_{14}$	Non-CCA	Prop. 2.9
	$k = 11$	$C_2 \times ((C_7 \times C_7) : C_2)$	CCA	Prop. 2.15
	$k = 12$	$C_{14} \times C_{14}$	CCA	Prop. 2.12
$n = 198$	$k = 1$	$C_{11} \times D_{18}$	CCA	Prop. 2.10
	$k = 2$	$C_9 \times D_{22}$	CCA	Prop. 2.10
	$k = 3$	D_{198}	CCA	Cor. 2.16
	$k = 4$	C_{198}	CCA	Prop. 2.12
	$k = 5$	$C_3 \times C_3 \times D_{22}$	CCA	Prop. 2.10
	$k = 6$	$C_{33} \times S_3$	Non-CCA	Prop. 2.9
	$k = 7$	$C_3 \times D_{66}$	Non-CCA	
	$k = 8$	$C_{11} \times ((C_3 \times C_3) : C_2)$	CCA	Prop. 2.10
	$k = 9$	$(C_{33} \times C_3) : C_2$	CCA	Prop. 2.15
	$k = 10$	$C_{66} \times C_3$	CCA	Prop. 2.12
$n = 200$	$k = 1$	$C_{25} : C_8$	CCA	
	$k = 2$	C_{200}	CCA	Prop. 2.12
	$k = 3$	$C_{25} : C_8$	Non-CCA	Prop. 2.3
	$k = 4$	$C_{25} : Q_8$	Non-CCA	Cor. 2.4
	$k = 5$	$C_4 \times D_{50}$	Non-CCA	Prop. 2.3
	$k = 6$	D_{200}	CCA	Cor. 2.16
	$k = 7$	$C_2 \times (C_{25} : C_4)$	Non-CCA	Prop. 2.9
	$k = 8$	$(C_{50} \times C_2) : C_2$	Non-CCA	Prop. 2.3
	$k = 9$	$C_{100} \times C_2$	Non-CCA	Prop. 2.12
	$k = 10$	$C_{25} \times D_8$	CCA	Prop. 2.10
	$k = 11$	$C_{25} \times Q_8$	Non-CCA	Prop. 2.9
	$k = 12$	$C_2 \times (C_{25} : C_4)$	Non-CCA	Prop. 2.9
	$k = 13$	$C_2 \times C_2 \times D_{50}$	CCA	Prop. 2.15
	$k = 14$	$C_{50} \times C_2 \times C_2$	CCA	Prop. 2.12
	$k = 15$	$C_5 \times (C_5 : C_8)$	Non-CCA	
	$k = 16$	$(C_5 \times C_5) : C_8$	CCA	
	$k = 17$	$C_{40} \times C_5$	CCA	Prop. 2.12
	$k = 18$	$C_5 \times (C_5 : C_8)$	Non-CCA	Prop. 2.3
	$k = 19$	$(C_5 \times C_5) : C_8$	Non-CCA	Prop. 2.3
	$k = 20$	$(C_5 \times C_5) : C_8$	Non-CCA	Prop. 2.3
	$k = 21$	$(C_5 \times C_5) : C_8$	Non-CCA	Prop. 2.3

$n=200$	$k=22$	$(C_5:C_4)\times D_{10}$	Non-CCA	Prop. 2.9
	$k=23$	$(C_5\times(C_5:C_4)):C_2$	Non-CCA	Prop. 2.3
	$k=24$	$(C_{10}\times D_{10}):C_2$	Non-CCA	Prop. 2.3
	$k=25$	$(C_{10}\times D_{10}):C_2$	Non-CCA	Prop. 2.3
	$k=26$	$(C_5\times C_5):Q_8$	Non-CCA	Prop. 2.3
	$k=27$	$C_5\times(C_5:Q_8)$	Non-CCA	Prop. 2.3
	$k=28$	$C_{20}\times D_{10}$	Non-CCA	Prop. 2.3
	$k=29$	$C_5\times D_{40}$	Non-CCA	
	$k=30$	$C_{10}\times(C_5:C_4)$	Non-CCA	Prop. 2.9
	$k=31$	$C_5\times((C_{10}\times C_2):C_2)$	Non-CCA	Prop. 2.9
	$k=32$	$(C_5\times C_5):Q_8$	Non-CCA	Cor. 2.4
	$k=33$	$C_4\times((C_5\times C_5):C_2)$	Non-CCA	Prop. 2.3
	$k=34$	$(C_{20}\times C_5):C_2$	CCA	Prop. 2.15
	$k=35$	$C_2\times((C_5\times C_5):C_4)$	Non-CCA	Prop. 2.9
	$k=36$	$(C_{10}\times C_{10}):C_2$	Non-CCA	Prop. 2.3
	$k=37$	$C_{20}\times C_{10}$	Non-CCA	Prop. 2.12
	$k=38$	$C_5\times C_5\times D_8$	CCA	Prop. 2.10
	$k=39$	$C_5\times C_5\times Q_8$	Non-CCA	Prop. 2.9
	$k=40$	$(C_5\times C_5):C_8$	Non-CCA	
	$k=41$	$D_{10}\times(C_5:C_4)$	Non-CCA	Prop. 2.9
	$k=42$	$((C_5\times C_5):C_4):C_2$	Non-CCA	Prop. 2.3
	$k=43$	$(D_{10}\times D_{10}):C_2$	Non-CCA	Prop. 2.3
	$k=44$	$(C_5\times C_5):Q_8$	Non-CCA	Prop. 2.3
	$k=45$	$C_{10}\times(C_5:C_4)$	Non-CCA	Prop. 2.9
	$k=46$	$C_2\times((C_5\times C_5):C_4)$	Non-CCA	Prop. 2.9
	$k=47$	$C_2\times((C_5\times C_5):C_4)$	Non-CCA	Prop. 2.9
	$k=48$	$C_2\times((C_5\times C_5):C_4)$	Non-CCA	Prop. 2.9
	$k=49$	$C_2\times D_{10}\times D_{10}$	Non-CCA	Prop. 2.9
	$k=50$	$C_2\times C_{10}\times D_{10}$	Non-CCA	Prop. 2.9
	$k=51$	$C_2\times C_2\times((C_5\times C_5):C_2)$	CCA	Prop. 2.15
	$k=52$	$C_{10}\times C_{10}\times C_2$	CCA	Prop. 2.12

The table below is read as follows; the first two columns represent the same as the first two columns of the table above. The third column represents the number of unique (up to automorphism) minimal generating sets there are for that group. Our algorithm ran for more than a week on one group ($C_2\times C_2\times C_2\times C_2\times D_{10}$, $n=160$, $k=237$) without completing. However, after making some modifications to the algorithm, D. W. Morris (personal communication) produced the answer that appears in this table with an asterisk.

n	*k*	*mgs*
8	1	1
8	2	2
8	3	2
8	4	1
8	5	1
12	1	4
12	2	3
12	3	3
12	4	5
12	5	4
16	1	1
16	2	1
16	3	2
16	4	2
16	5	4
16	6	4
16	7	2
16	8	3
16	9	2
16	10	3
16	11	6
16	12	3
16	13	7
16	14	1
18	1	2
18	2	4
18	3	9
18	4	3
18	5	3
20	1	4
20	2	3
20	3	7
20	4	5
20	5	5
21	1	5
21	2	2
24	1	8
24	2	5
24	3	10

n	*k*	*mgs*
24	4	8
24	5	13
24	6	8
24	7	8
24	8	13
24	9	11
24	10	11
24	11	5
24	12	14
24	13	10
24	14	12
24	15	6
28	1	4
28	2	3
28	3	5
28	4	6
32	1	1
32	2	1
32	3	2
32	4	2
32	5	4
32	6	4
32	7	2
32	8	2
32	9	3
32	10	3
32	11	6
32	12	4
32	13	2
32	14	2
32	15	4
32	16	8
32	17	8
32	18	2
32	19	3
32	20	2
32	21	3
32	22	6
32	23	6

n	*k*	*mgs*
32	24	10
32	25	16
32	26	7
32	27	7
32	28	16
32	29	16
32	30	16
32	31	10
32	32	8
32	33	10
32	34	3
32	35	6
32	36	9
32	37	22
32	38	23
32	39	11
32	40	20
32	41	11
32	42	30
32	43	32
32	44	32
32	45	4
32	46	13
32	47	6
32	48	33
32	49	19
32	50	14
32	51	1
36	1	4
36	2	7
36	3	7
36	4	9
36	5	13
36	6	22
36	7	9
36	8	7
36	9	4
36	10	26
36	11	8

n	*k*	*mgs*
36	12	49
36	13	10
36	14	6
40	1	8
40	2	5
40	3	14
40	4	8
40	5	13
40	6	8
40	7	8
40	8	13
40	9	14
40	10	14
40	11	6
40	12	24
40	13	14
40	14	10
42	1	15
42	2	18
42	3	15
42	4	9
42	5	5
42	6	14
44	1	4
44	2	3
44	3	5
44	4	8
48	1	14
48	2	9
48	3	3
48	4	42
48	5	42
48	6	21
48	7	12
48	8	12
48	9	27
48	10	27
48	11	13
48	12	23

n	*k*	*mgs*
48	13	14
48	14	23
48	15	23
48	16	23
48	17	23
48	18	23
48	19	13
48	20	6
48	21	14
48	22	15
48	23	29
48	24	29
48	25	14
48	26	24
48	27	14
48	28	39
48	29	39
48	30	41
48	31	24
48	32	24
48	33	24
48	34	35
48	35	62
48	36	35
48	37	104
48	38	106
48	39	106
48	40	43
48	41	43
48	42	16
48	43	62
48	44	29
48	45	70
48	46	29
48	47	85
48	48	78
48	49	20
48	50	5
48	51	26

n	*k*	*mgs*
48	52	9
50	1	2
50	2	6
50	3	12
50	4	3
50	5	3
52	1	4
52	2	3
52	3	7
52	4	5
52	5	9
54	1	2
54	2	10
54	3	12
54	4	34
54	5	12
54	6	23
54	7	8
54	8	37
54	9	15
54	10	4
54	11	26
54	12	15
54	13	26
54	14	4
54	15	4
56	1	8
56	2	5
56	3	8
56	4	13
56	5	8
56	6	8
56	7	13
56	8	17
56	9	17
56	10	7
56	11	9
56	12	17
56	13	16

n	*k*	*mgs*
60	1	28
60	2	22
60	3	16
60	4	25
60	5	27
60	6	37
60	7	24
60	8	55
60	9	17
60	10	52
60	11	90
60	12	31
60	13	43
63	1	13
63	2	4
63	3	13
63	4	6
64	1	1
64	2	1
64	3	2
64	4	4
64	5	4
64	6	6
64	7	6
64	8	6
64	9	6
64	10	4
64	11	3
64	12	2
64	13	3
64	14	2
64	15	4
64	16	4
64	17	2
64	18	2
64	19	1
64	20	3
64	21	2
64	22	2

n	*k*	*mgs*
64	23	2
64	24	2
64	25	3
64	26	4
64	27	4
64	28	7
64	29	8
64	30	8
64	31	12
64	32	6
64	33	6
64	34	4
64	35	4
64	36	4
64	37	4
64	38	3
64	39	3
64	40	6
64	41	6
64	42	3
64	43	3
64	44	8
64	45	8
64	46	6
64	47	2
64	48	2
64	49	4
64	50	14
64	51	14
64	52	2
64	53	3
64	54	2
64	55	1
64	56	3
64	57	3
64	58	10
64	59	10
64	60	3
64	61	10

n	*k*	*mgs*
64	62	6
64	63	6
64	64	4
64	65	3
64	66	16
64	67	16
64	68	28
64	69	28
64	70	16
64	71	10
64	72	10
64	73	7
64	74	7
64	75	16
64	76	7
64	77	10
64	78	16
64	79	16
64	80	7
64	81	16
64	82	2
64	83	12
64	84	12
64	85	20
64	86	32
64	87	22
64	88	22
64	89	36
64	90	40
64	91	40
64	92	22
64	93	22
64	94	36
64	95	20
64	96	20
64	97	32
64	98	32
64	99	20
64	100	20

n	*k*	*mgs*
64	101	72
64	102	72
64	103	22
64	104	22
64	105	32
64	106	11
64	107	11
64	108	18
64	109	32
64	110	40
64	111	32
64	112	40
64	113	40
64	114	56
64	115	60
64	116	112
64	117	60
64	118	30
64	119	56
64	120	30
64	121	56
64	122	30
64	123	30
64	124	116
64	125	116
64	126	23
64	127	60
64	128	32
64	129	32
64	130	56
64	131	32
64	132	32
64	133	56
64	134	60
64	135	60
64	136	60
64	137	60
64	138	46
64	139	46

n	*k*	*mgs*
64	140	32
64	141	32
64	142	32
64	143	32
64	144	56
64	145	56
64	146	56
64	147	30
64	148	30
64	149	56
64	150	30
64	151	30
64	152	112
64	153	60
64	154	60
64	155	32
64	156	32
64	157	32
64	158	32
64	159	56
64	160	56
64	161	32
64	162	32
64	163	56
64	164	32
64	165	32
64	166	56
64	167	20
64	168	20
64	169	28
64	170	32
64	171	16
64	172	16
64	173	10
64	174	6
64	175	6
64	176	16
64	177	16
64	178	16

n	*k*	*mgs*
64	179	11
64	180	16
64	181	11
64	182	32
64	183	29
64	184	78
64	185	83
64	186	20
64	187	38
64	188	20
64	189	58
64	190	64
64	191	64
64	192	6
64	193	13
64	194	13
64	195	48
64	196	81
64	197	33
64	198	90
64	199	68
64	200	29
64	201	90
64	202	33
64	203	81
64	204	81
64	205	81
64	206	237
64	207	48
64	208	41
64	209	51
64	210	444
64	211	13
64	212	28
64	213	135
64	214	126
64	215	122
64	216	138
64	217	138

n	*k*	*mgs*
64	218	122
64	219	426
64	220	426
64	221	222
64	222	222
64	223	444
64	224	40
64	225	122
64	226	122
64	227	444
64	228	237
64	229	166
64	230	90
64	231	90
64	232	426
64	233	444
64	234	444
64	235	237
64	236	122
64	237	237
64	238	90
64	239	19
64	240	122
64	241	148
64	242	29
64	243	214
64	244	219
64	245	16
64	246	17
64	247	74
64	248	204
64	249	187
64	250	38
64	251	70
64	252	38
64	253	279
64	254	300
64	255	300
64	256	481

n	*k*	*mgs*
64	257	315
64	258	610
64	259	315
64	260	5
64	261	23
64	262	10
64	263	101
64	264	133
64	265	94
64	266	177
64	267	1
68	1	4
68	2	3
68	3	7
68	4	5
68	5	11
72	1	8
72	2	13
72	3	26
72	4	16
72	5	29
72	6	16
72	7	16
72	8	29
72	9	49
72	10	49
72	11	19
72	12	58
72	13	29
72	14	18
72	15	26
72	16	39
72	17	37
72	18	37
72	19	8
72	20	107
72	21	58
72	22	57
72	23	107

n	*k*	*mgs*
72	24	57
72	25	40
72	26	96
72	27	174
72	28	96
72	29	97
72	30	174
72	31	23
72	32	41
72	33	23
72	34	24
72	35	41
72	36	28
72	37	28
72	38	12
72	39	14
72	40	22
72	41	9
72	42	151
72	43	111
72	44	53
72	45	14
72	46	225
72	47	59
72	48	194
72	49	24
72	50	12
76	1	4
76	2	3
76	3	5
76	4	12
80	1	14
80	2	9
80	3	26
80	4	42
80	5	42
80	6	21
80	7	12
80	8	12

n	*k*	*mgs*
80	9	27
80	10	27
80	11	13
80	12	23
80	13	14
80	14	23
80	15	23
80	16	23
80	17	23
80	18	23
80	19	13
80	20	7
80	21	17
80	22	18
80	23	35
80	24	35
80	25	17
80	26	30
80	27	17
80	28	39
80	29	41
80	30	39
80	31	41
80	32	41
80	33	39
80	34	39
80	35	42
80	36	76
80	37	42
80	38	132
80	39	134
80	40	134
80	41	52
80	42	52
80	43	18
80	44	76
80	45	53
80	46	138
80	47	53

n	*k*	*mgs*
80	48	173
80	49	4
80	50	103
80	51	41
80	52	20
81	1	1
81	2	1
81	3	3
81	4	5
81	5	7
81	6	13
81	7	7
81	8	7
81	9	3
81	10	4
81	11	5
81	12	5
81	13	26
81	14	39
81	15	1
84	1	34
84	2	44
84	3	34
84	4	22
84	5	16
84	6	29
84	7	91
84	8	63
84	9	40
84	10	21
84	11	13
84	12	55
84	13	147
84	14	35
84	15	61
88	1	8
88	2	5
88	3	8
88	4	13

n	*k*	*mgs*
88	5	8
88	6	8
88	7	13
88	8	23
88	9	23
88	10	9
88	11	21
88	12	30
90	1	15
90	2	34
90	3	9
90	4	40
90	5	16
90	6	114
90	7	53
90	8	50
90	9	14
90	10	36
92	1	4
92	2	3
92	3	5
92	4	14
96	1	26
96	2	17
96	3	10
96	4	148
96	5	148
96	6	20
96	7	37
96	8	20
96	9	24
96	10	24
96	11	50
96	12	74
96	13	74
96	14	43
96	15	43
96	16	43
96	17	43

n	*k*	*mgs*
96	18	86
96	19	86
96	20	41
96	21	78
96	22	41
96	23	39
96	24	22
96	25	22
96	26	44
96	27	78
96	28	39
96	29	78
96	30	39
96	31	39
96	32	78
96	33	39
96	34	39
96	35	39
96	36	39
96	37	48
96	38	24
96	39	43
96	40	24
96	41	48
96	42	43
96	43	24
96	44	86
96	45	9
96	46	21
96	47	21
96	48	42
96	49	42
96	50	21
96	51	21
96	52	36
96	53	36
96	54	72
96	55	44
96	56	21

n	*k*	*mgs*
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96	58	42
96	59	84
96	60	84
96	61	20
96	62	36
96	63	20
96	64	70
96	65	133
96	66	127
96	67	129
96	68	18
96	69	64
96	70	16
96	71	29
96	72	16
96	73	64
96	74	64
96	75	148
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96	79	146
96	80	148
96	81	20
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96	83	92
96	84	146
96	85	272
96	86	272
96	87	146
96	88	272
96	89	146
96	90	272
96	91	272
96	92	272
96	93	146
96	94	152
96	95	152

n	*k*	*mgs*
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96	98	152
96	99	152
96	100	152
96	101	272
96	102	152
96	103	272
96	104	152
96	105	272
96	106	313
96	107	313
96	108	544
96	109	168
96	110	88
96	111	268
96	112	88
96	113	570
96	114	552
96	115	286
96	116	286
96	117	271
96	118	520
96	119	271
96	120	520
96	121	520
96	122	520
96	123	520
96	124	271
96	125	520
96	126	271
96	127	73
96	128	182
96	129	49
96	130	90
96	131	148
96	132	51
96	133	82
96	134	90

n	*k*	*mgs*
96	135	272
96	136	146
96	137	148
96	138	175
96	139	298
96	140	175
96	141	152
96	142	144
96	143	85
96	144	144
96	145	152
96	146	272
96	147	85
96	148	175
96	149	298
96	150	175
96	151	85
96	152	63
96	153	152
96	154	85
96	155	215
96	156	292
96	157	544
96	158	292
96	159	49
96	160	56
96	161	32
96	162	80
96	163	82
96	164	142
96	165	256
96	166	99
96	167	94
96	168	256
96	169	256
96	170	252
96	171	142
96	172	128
96	173	160

n	*k*	*mgs*
96	174	32
96	175	80
96	176	115
96	177	304
96	178	355
96	179	151
96	180	288
96	181	151
96	182	490
96	183	508
96	184	508
96	185	171
96	186	315
96	187	171
96	188	168
96	189	168
96	190	311
96	191	169
96	192	311
96	193	169
96	194	172
96	195	315
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96	197	101
96	198	40
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96	204	198
96	205	128
96	206	230
96	207	128
96	208	1027
96	209	1031
96	210	1031
96	211	1756
96	212	386

n	*k*	*mgs*
96	213	386
96	214	657
96	215	2368
96	216	1233
96	217	1233
96	218	31
96	219	230
96	220	65
96	221	302
96	222	119
96	223	964
96	224	583
96	225	381
96	226	302
96	227	94
96	228	44
96	229	28
96	230	50
96	231	12
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100	6	28
100	7	9
100	8	7
100	9	49
100	10	24
100	11	16
100	12	11
100	13	34
100	14	93
100	15	10

n	*k*	*mgs*
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104	2	5
104	3	14
104	4	8
104	5	13
104	6	8
104	7	8
104	8	13
104	9	26
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104	11	10
104	12	24
104	13	24
104	14	40
105	1	31
105	2	17
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108	9	66
108	10	27
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108	14	76
108	15	30
108	16	156
108	17	241
108	18	39
108	19	71
108	20	15
108	21	26
108	22	14

n	*k*	*mgs*
108	23	132
108	24	395
108	25	134
108	26	261
108	27	46
108	28	234
108	29	55
108	30	14
108	31	97
108	32	57
108	33	99
108	34	17
108	35	13
108	36	20
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108	38	458
108	39	141
108	40	89
108	41	24
108	42	129
108	43	169
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112	1	14
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112	11	23
112	12	14
112	13	23
112	14	23
112	15	23
112	16	23

n	*k*	*mgs*
112	17	23
112	18	13
112	19	8
112	20	20
112	21	21
112	22	41
112	23	41
112	24	20
112	25	36
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112	27	49
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112	33	62
112	34	62
112	35	21
112	36	90
112	37	87
112	38	234
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112	41	34
112	42	63
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116	1	4
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116	3	7
116	4	5
116	5	17
120	1	70
120	2	58
120	3	52
120	4	57
120	5	133
120	6	96
120	7	82

n	*k*	*mgs*
120	8	123
120	9	123
120	10	123
120	11	123
120	12	123
120	13	123
120	14	123
120	15	72
120	16	102
120	17	186
120	18	102
120	19	103
120	20	186
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120	24	176
120	25	328
120	26	66
120	27	121
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120	35	193
120	36	417
120	37	276
120	38	98
120	39	57
120	40	339
120	41	224
120	42	653
120	43	133
120	44	247
120	45	486
120	46	132

n	k	mgs
120	47	145
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126	8	108
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126	12	166
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126	16	53
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132	10	109
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136	7	8
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n	k	mgs
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140	4	33
140	5	61
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144	19	29
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n	k	mgs
144	22	79
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144	25	76
144	26	144
144	27	76
144	28	158
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144	41	502
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144	45	57
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144	47	249
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144	56	137
144	57	255
144	58	264
144	59	255
144	60	255

n	k	mgs
144	61	137
144	62	255
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144	64	275
144	65	144
144	66	275
144	67	144
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144	80	372
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144	82	372
144	83	372
144	84	198
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144	88	54
144	89	54
144	90	117
144	91	115
144	92	60
144	93	112
144	94	63
144	95	112
144	96	106
144	97	106
144	98	106
144	99	106

n	*k*	*mgs*
144	100	60
144	101	22
144	102	57
144	103	62
144	104	115
144	105	115
144	106	56
144	107	103
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144	109	256
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144	115	76
144	116	38
144	117	38
144	118	76
144	119	38
144	120	35
144	121	555
144	122	555
144	123	571
144	124	484
144	125	484
144	126	496
144	127	206
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144	129	208
144	130	23
144	131	23
144	132	22
144	133	24
144	134	23
144	135	23
144	136	22
144	137	1401
144	138	1401

n	*k*	*mgs*
144	139	1414
144	140	731
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144	142	1401
144	143	1358
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144	146	780
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144	148	1356
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144	153	2666
144	154	1358
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144	156	214
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144	174	142
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n	*k*	*mgs*
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144	180	88
144	181	266
144	182	132
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n	*k*	*mgs*
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152	11	31
152	12	76
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156	5	16
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156	18	139
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n	k	mgs
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160	39	43
160	40	24
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160	42	43
160	43	24

n	k	mgs
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n	k	mgs
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160	84	132
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160	86	71
160	87	71
160	88	71
160	89	176
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160	116	180
160	117	328
160	118	180
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160	120	369
160	121	369

n	k	mgs
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160	123	196
160	124	102
160	125	324
160	126	102
160	127	682
160	128	664
160	129	342
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160	131	327
160	132	632
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160	134	632
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160	142	210
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160	155	180
160	156	172
160	157	99
160	158	172
160	159	180
160	160	328

n	*k*	*mgs*
160	161	99
160	162	203
160	163	354
160	164	203
160	165	99
160	166	72
160	167	180
160	168	99
160	169	252
160	170	348
160	171	656
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160	173	56
160	174	65
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160	178	274
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160	182	512
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160	186	256
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160	190	207
160	191	572
160	192	699
160	193	285
160	194	552
160	195	285
160	196	998
160	197	1020
160	198	1020
160	199	42

n	*k*	*mgs*
160	200	344
160	201	352
160	202	634
160	203	344
160	204	352
160	205	634
160	206	1210
160	207	1210
160	208	442
160	209	442
160	210	138
160	211	344
160	212	344
160	213	221
160	214	408
160	215	221
160	216	2029
160	217	2033
160	218	2033
160	219	3680
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160	221	729
160	222	1313
160	223	4934
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160	225	2530
160	226	46
160	227	408
160	228	173
160	229	929
160	230	343
160	231	3236
160	232	2020
160	233	1274
160	234	21
160	235	14
160	236	487
160	237	108*
160	238	34

n	*k*	*mgs*
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162	2	28
162	3	61
162	4	61
162	5	21
162	6	121
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162	18	17
162	19	387
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162	21	136
162	22	254
162	23	8
162	24	27
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162	26	78
162	27	146
162	28	75
162	29	75
162	30	27
162	31	48
162	32	39
162	33	154
162	34	149
162	35	38
162	36	276
162	37	277
162	38	97
162	39	203

n	*k*	*mgs*
162	40	96
162	41	194
162	42	186
162	43	454
162	44	343
162	45	21
162	46	753
162	47	37
162	48	34
162	49	216
162	50	390
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162	53	61
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162	55	5
164	1	4
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164	3	7
164	4	5
164	5	23
168	1	84
168	2	120
168	3	82
168	4	58
168	5	52
168	6	65
168	7	177
168	8	324
168	9	177
168	10	177
168	11	324
168	12	139
168	13	139
168	14	139
168	15	139
168	16	139
168	17	139
168	18	139

n	*k*	*mgs*
168	19	209
168	20	209
168	21	83
168	22	88
168	23	74
168	24	108
168	25	198
168	26	108
168	27	109
168	28	198
168	29	286
168	30	546
168	31	286
168	32	287
168	33	546
168	34	74
168	35	137
168	36	74
168	37	76
168	38	137
168	39	284
168	40	284
168	41	106
168	42	95
168	43	142
168	44	43
168	45	451
168	46	111
168	47	578
168	48	61
168	49	99
168	50	941
168	51	111
168	52	199
168	53	121
168	54	312
168	55	1014
168	56	184
168	57	262

n	*k*	*mgs*
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172	3	5
172	4	24
176	1	14
176	2	9
176	3	42
176	4	42
176	5	21
176	6	12
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176	26	26
176	27	63
176	28	118
176	29	63
176	30	216
176	31	218
176	32	218
176	33	80
176	34	80
176	35	25

n	*k*	*mgs*
176	36	118
176	37	181
176	38	510
176	39	181
176	40	661
176	41	117
176	42	103
180	1	40
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180	3	32
180	4	97
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180	7	180
180	8	58
180	9	422
180	10	245
180	11	95
180	12	274
180	13	61
180	14	388
180	15	210
180	16	191
180	17	60
180	18	118
180	19	275
180	20	100
180	21	348
180	22	103
180	23	26
180	24	14
180	25	21
180	26	1089
180	27	213
180	28	1086
180	29	625
180	30	327
180	31	146
180	32	160

n	*k*	*mgs*
180	33	1669
180	34	574
180	35	439
180	36	115
180	37	172
184	1	8
184	2	5
184	3	8
184	4	13
184	5	8
184	6	8
184	7	13
184	8	41
184	9	41
184	10	15
184	11	35
184	12	106
188	1	4
188	2	3
188	3	5
188	4	26
189	1	37
189	2	10
189	3	71
189	4	71
189	5	71
189	6	27
189	7	46
189	8	25
189	9	26
189	10	7
189	11	47
189	12	56
189	13	16
196	1	4
196	2	15
196	3	17
196	4	57
196	5	34

n	*k*	*mgs*
196	6	9
196	7	7
196	8	4
196	9	42
196	10	153
196	11	10
196	12	8
198	1	24
198	2	34
198	3	9
198	4	58
198	5	19
198	6	306
198	7	62
198	8	178
198	9	21
198	10	99
200	1	8
200	2	21
200	3	14
200	4	24
200	5	45
200	6	24
200	7	24
200	8	45
200	9	126
200	10	126
200	11	46
200	12	80
200	13	84
200	14	180
200	15	70
200	16	29
200	17	18
200	18	120
200	19	82
200	20	54
200	21	36
200	22	139

n	*k*	*mgs*
200	23	74
200	24	73
200	25	139
200	26	73
200	27	181
200	28	340
200	29	181
200	30	182
200	31	340
200	32	23
200	33	41
200	34	23
200	35	24
200	36	41
200	37	34
200	38	34
200	39	14
200	40	14
200	41	473
200	42	220
200	43	31
200	44	9
200	45	609
200	46	252
200	47	69
200	48	119
200	49	461
200	50	581
200	51	27
200	52	20