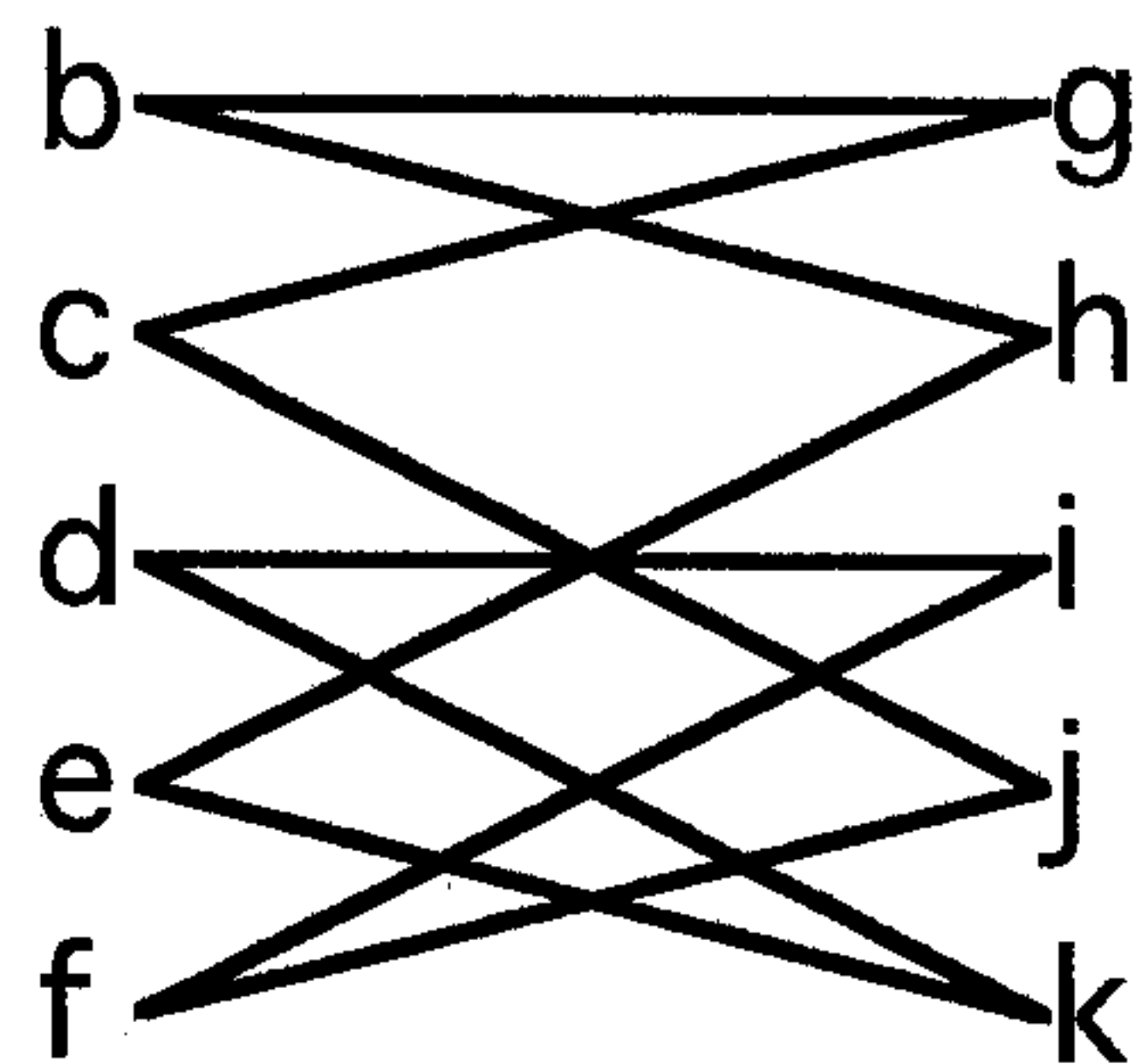


1. Give the cycle structure representation for a 120 degree rotation of the corners of a 12-gon.
2. a) Construct the matching network and make a flow corresponding to the partial matching b-g, d-i, e-h, f-j.
b) Apply the Augmenting Flow Algorithm (show ALL labels) and from it obtain a complete matching.

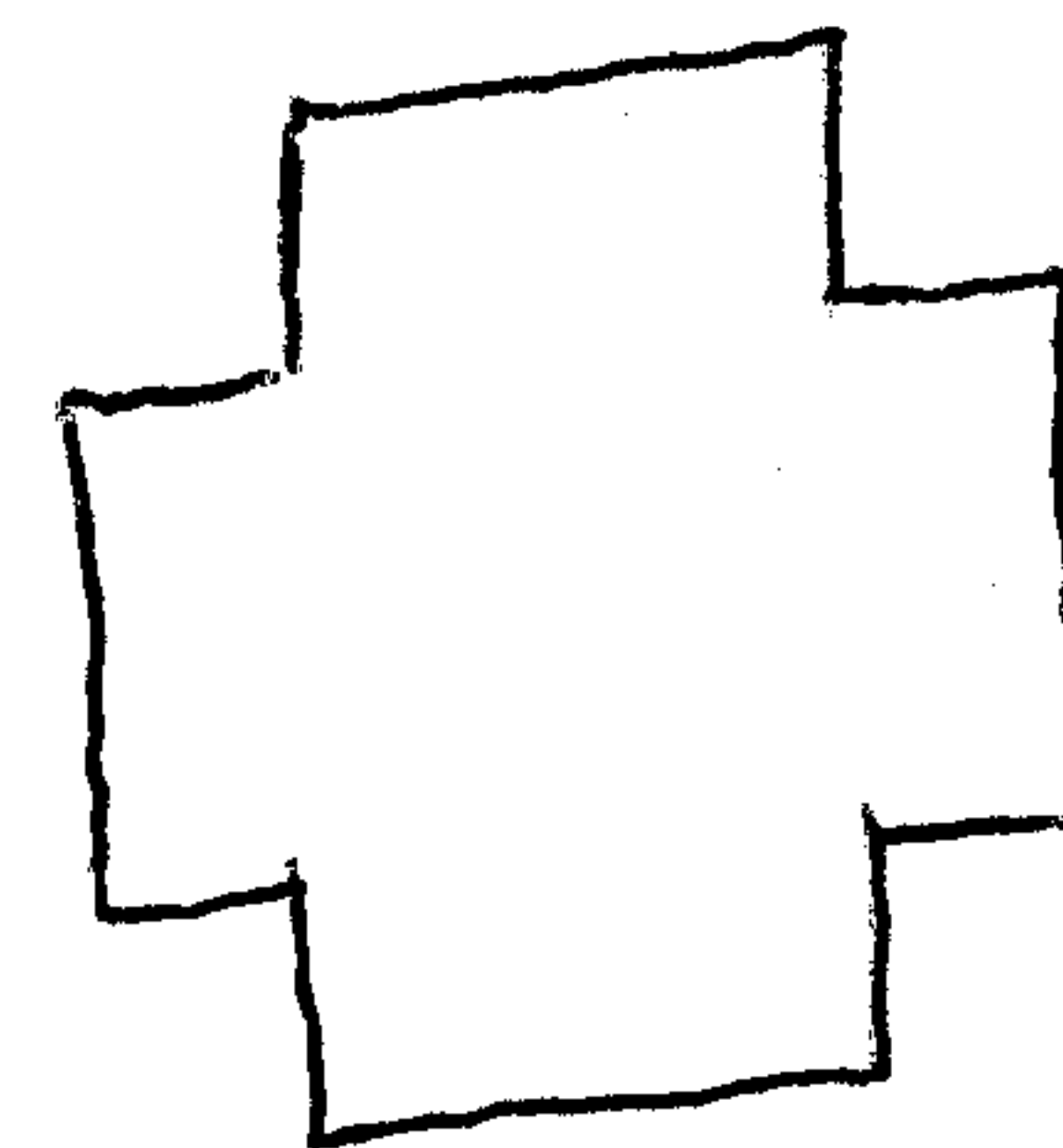


3. a) Consider the game of Nim on the right.

 A player can remove any number of objects (exactly) one of the three piles. Find the Grundy number for this position and explain how to move to a position in the kernel.

b) Repeat part a) now with the constraint that a player must remove exactly 1 or 3 or 4 objects from a pile.

4. Give an expression for the pattern inventory of EDGE 2-colorings of the unoriented figure on the right (rotations and flips allowed).



5. Do one of the following two problems

I. For any set S of vertices in the directed graph G , let $W(S)$ denote the set of vertices in G that have NO edge directed to any vertex in S ($W(S)$ is the set of vertices that cannot move directly to any vertex in S). Show that S is a kernel if $W(S) = S$.

II. In the following table of remaining games, it is possible for the Vikings to be champions (or co-champions) if they win all remaining games? Build the appropriate network model and flow.

Team	Wins to date	Games to play	with Vikings	with Romans	with Huns	with Mongols
Vikings	21	7	—	2	2	3
Romans	26	5	2	—	1	2
Huns	27	4	2	1	—	1
Mongols	24	6	3	2	1	—