1. (i) `8*7*6*5*4 = 6720`

   (ii) 32.

   (iii) `(26 choose 20)*19*17*15*13*11*9*7*5*3*1 = 150738274937250`

   `150738274937250/100391791500=1501.5`

   (iv) There were only 6 rotor arrangements before, now there are 24 `(4*3*2=24)`, so the number of keys increases only by a factor of 4.

2. remaining prefixes: `LQUFGD PFNWOL ULMKAJ`

   ```
   1-4 permutation D E O S Z I V T N M C F Q P J W R Y X B K H G U A L
   cycles A D S X U K C O J M Q R Y
          B E Z L F I N P W G V H T fingerprint 13-13

   2-5 permutation B N C R D O L E Z J H A K W F Y G I V S X Q T M P U
   cycles A B N W T S V Q G L
          C
          D R I Z U X M K H E
          F O
          J
          P Y                    fingerprint 10-10-2-2-1-1

   3-6 permutation F C M Z Q P N G R X Y V J L K E U B I W D H O S T A
   cycles A F P E Q U D Z
          B C M J X S I R
          G N L V H
          K Y T W O fingerprint 8-8-5-5
   ```

3. the unique choice for the permutation image of the 26th character is the one character that has not appeared as a permutation image so far

4. (i) other positions 1,2,4,6,7,8,11,13,14,15

   (ii) `9-11-16 e-n-o`

   (iii) starting with letter X in position 9 creates the `9-11-16-9` cycle.

   ```
           .  .   .
   AAAAAAAAXANAAAAO
   KTWREEOSNUODOPLX
   ```

   (iv) `EX JL QS RZ TY`

   (v) `XXXXWETTERNULLSECHSBREMENMITTAG`

5. All three. This greatly reduces the number of rotor settings that would match the fingerprints.

   the Germans changed their key exchange protocol, so the number of messages broken dropped dramatically until Turing's machine arrived

6. `weasel ice nut deer ...`

   `gloe-ih tkin nesh-chee be ...`

7. it was an oral code, no Navajo was ever written