Question Sheet: B physics and CP Violation.

1) Construct a CP-quadrant figure (similar to the one in lectures) for (an imaginary) theory which is:
   a) P-violating (not maximally) but C-conserving.
   b) C-violating (not maximally) but P-conserving.
   In both cases explain whether the theories are CP-violating and whether there is an observable particle/anti-particle asymmetry.
2) Consider a process i→f having two intermediate states (1 and 2). Each amplitude has two components a_i and α_i such that under CP:
   $a_i \rightarrow a_i$
   $\alpha_i \rightarrow \alpha_i^*$.
   Show that the CP asymmetry is of the form:
   $$\frac{\Gamma(i \to f) - \Gamma(\bar{i} \to \bar{f})}{\Gamma(i \to f) + \Gamma(\bar{i} \to \bar{f})} \propto \mathrm{Im}(a_1 a_2^*)\,\mathrm{Im}(\mathbf{a}_1 \mathbf{a}_2^*)$$
   $$\propto \sin\left[Arg(a_1) - Arg(a_2)\right]\sin\left[Arg(\mathbf{a}_1) - Arg(\mathbf{a}_2)\right]$$
   and find the constant of proportionality.

3) Write down the six unitarity conditions for the 3x3 CKM triangle. Make sketches of the six triangles and calculate their areas to lowest order in the Wolfenstein parameterisation of the CKM matrix.

4) Consider direct CP violation in the process $B^- \rightarrow K^- \pi^0$. Show that the associated CP violating asymmetry is proportional to
   $$\sum_{i \neq j} \mathrm{Im}(A_i A_j^*)\,\mathrm{Im}(l_i l_j^*)$$
   where $l_i = V_{ib} V_{is}^*$ and i and j are any two charge 2/3 quarks. Hence show that the asymmetry is proportional to the area of the unitarity triangle. Use the unitarity condition to show that there would exits no CP violation for this type of decay if there were only two generations.