QCD and collider physics - Problem sheet

Problem 1

Derive the Feynman rule for the 4 gluon vertex using the general rules discussed during the lecture to extract the Feynman rules directly from the Lagrangian.

Problem 2

The gauge invariance implies (as in QED) that $M_{fi} = 0$ when the polarization vector of an exernal gluon is replaced by its momentum.

a) Verify the gauge invariance of the QCD-Compton process $g + q \to g + q$, i.e., verify that

$$M_{fi}(\epsilon^a_\mu(k) \to k_\mu) = 0\,.$$

Hint : There are three Feynman diagrams which contribute at the lowest order. In particular, the three-gluon vertex plays a role in one of the diagrams.

b) Discuss qualitatively the gauge invariance of the process $g + g \to g + g$.

Problem 3

a) Show that the electric charges in QED are not quantized, i.e., there is no restriction on the charge Q in the covariant derivative $D_\mu = \partial_\mu + iQeA_\mu$.

b) Show that this is different in non-Abelian theories.
Hint : Verify the gauge invariance using a covariant derivative of the form $D_\mu = \partial_\mu + i\lambda_q g G_\mu$.