Molecular Imaging

5% of total											
Question	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	**Total**
Points	1	2	2	1	1	2	4	4	2	3	22
Score											

Molecular imaging is a powerful tool in medical diagnostics. The nuclear isomer ^{99m}Tc (m = metastable) of the isotope ^{99g}Tc (g = ground state) has excellent radiation properties ($\gamma-$ emitter, $t_{1/2}$= 6.015 h) for radioimaging. ^{99m}Tc is obtained by β^- decay of a mother nuclide in a so-called technetium generator as ^{99m}Tc-pertechnetate [^{99m}TcO$_4$]$^-$.

1.1 **Identify** the mother nuclide (**A**) of ^{99m}Tc and and the emitted particle (**B**). 1.0pt

A $\longrightarrow$ $^{99m}\mathrm{Tc}$ + **B**

1.2 **Provide** the oxidation states of the radiometal in the following ^{99m}Tc-probes **on the answer sheet.** 2.0pt

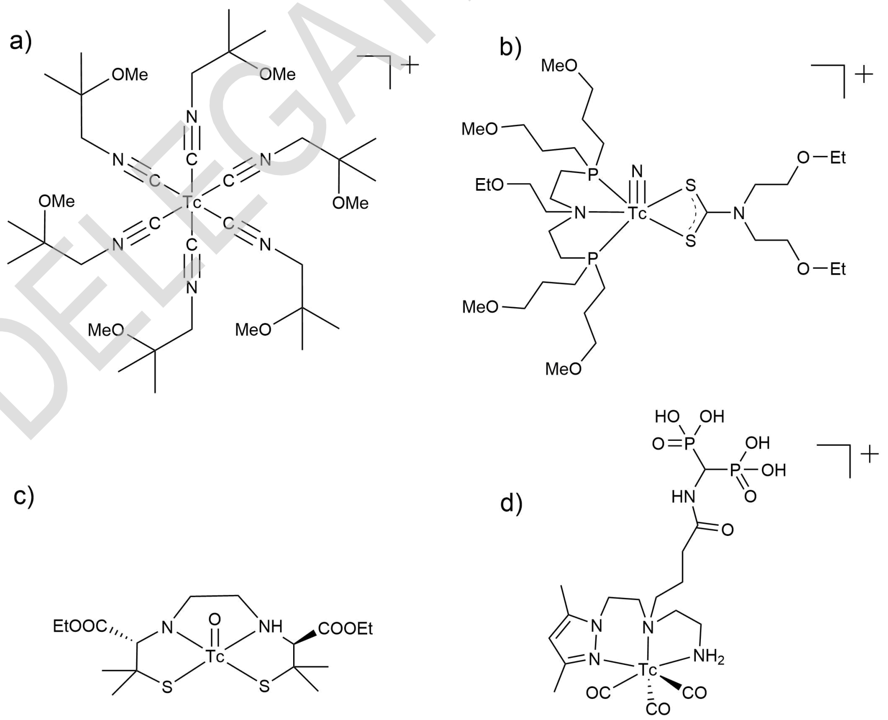


Figure 1. a) ^{99m}Tc-Sestamibi (Cardiolite) heart imaging, b) ^{99m}Tc-DBODC5 heart imaging, c) Neurolite® brain imaging d) bone imaging

The redox potentials of the group seven elements manganese (**Mn**), technetium (**Tc**) and rhenium (**Re**) follow the general trend in the periodic tables (see **Figure 2** below).

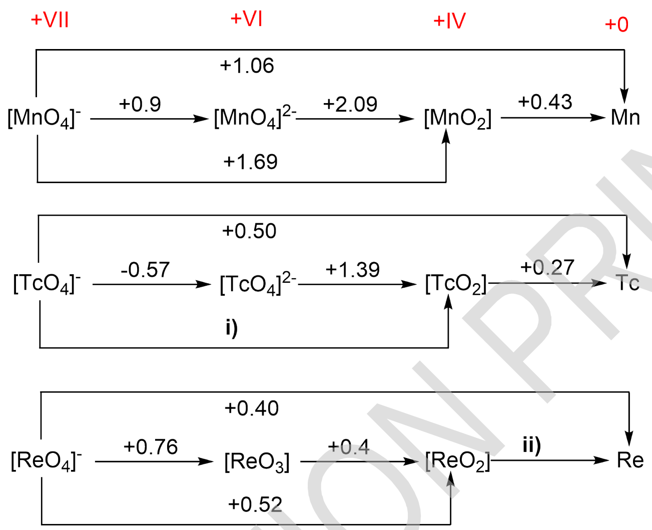


Figure 2: Latimer diagram of the manganese triad for acidic conditions vs. standard hydrogen electrode (SHE), potentials given in Volt.

1.3	**Calculate** the two missing redox potentials **i)** and **ii)**.	2.0pt

1.4	Compare $[MnO_4]^-$, $[TcO_4]^-$ and $[ReO_4]^-$. **Choose** the strongest oxidizing agent and **tick** your answer on the answer sheet.	1.0pt

1.5	Based on the values indicated by **Figure 2** above, **select** if TcO_2 would disproportionate to Tc and TcO_4^{2-} under acidic conditions.	1.0pt

Tc and Re complexes at the oxidation state +V (d^2 systems) which contain a terminal oxo- (O=) or nitrido-ligand (N≡) are diamagnetic. The scheme on the answer sheet shows three possible molecular orbital energy diagrams.

1.6	**Choose** which orbital energy diagram explains the observed diamagnetism and **tick** your answer. **Draw** the corresponding electron configuration in the correct diagram on your answer sheet.	2.0pt

$((C_4H_9)_4N)[^{99g}TcO_4]$ is a colorless powder. By the addition of conc. HCl this common starting compound for ^{99g}Tc chemistry is converted into the green complex $((C_4H_9)_4N)[^{99g}TcOCl_4]$.

1.7	**Write** down both oxidation and reduction half-reactions using the formulas of ions or neutral molecules, and the complete redox reaction.	4.0pt

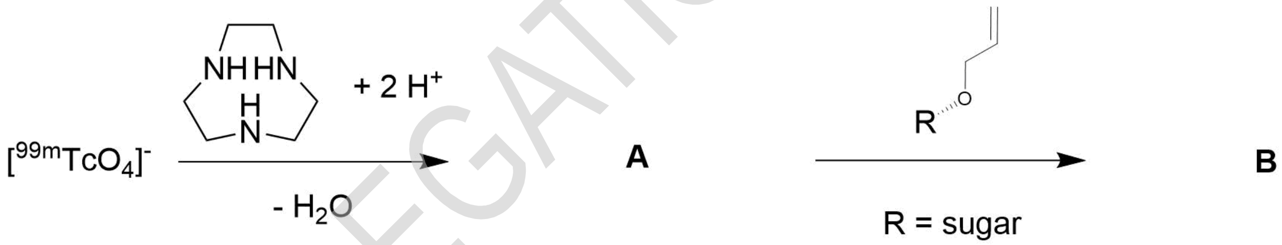
All ^{99m}Tc radiotracers in clinics are prepared in “one pot” reactions, applying commercialized kits (^{99m}Tc t1/2= 6.015 h). Typically, an eluate of a ^{99m}Tc generator has an activity of $12.5\ \mathrm{GBq}$ ($\mathrm{GBq} = \text{giga Becquerel} = 10^9 \text{decays per second}$).

1.8	**Calculate** how many mol ^{99m}Tc are present in such samples.	4.0pt

For standard imaging, around $200\ \mathrm{MBq}$ ^{99m}Tc are administered to the patient.

1.9	Assume that no activity is lost through excretion. **Calculate** how many hours the patient has to wait until the injected activity decreases to under 1% of the starting activity.	2.0pt

Bioconjugation of radiometals is a chemical challenge. A recent example is the (3+2) cycloaddition of [^{99m}TcO_3(tacn)]$^+$ (**A**) (tacn = 1,4,7-triazacyclononane) with alkenes. In this context (3 + 2) refers to the number of atoms involved and not to the numbers of electrons. The following scheme shows an example of this reaction by labeling a protected carbohydrate.



1.10	**Draw** the structures of compound **A** and **B** on your answer sheet. Further, **state** the oxidation state of the technetium in these compounds.	3.0pt