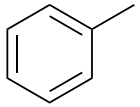
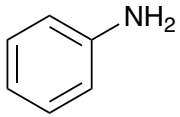
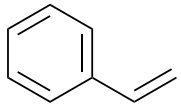
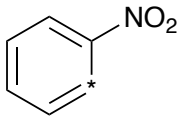
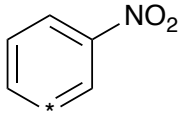
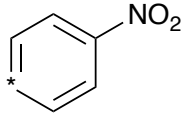
Chem 12

Final Exam (2022 Spring)

Grading Scheme

General Grading Principles

- All participants receive equal treatment.
- Grading schemes are used positively. Participants will be rewarded if they have given the relevant work rather than penalized for omissions.
- All the points on the grading scheme are designed to be awarded. Participants will always receive full points if deserved, i.e. if the answer matches the grading scheme. Participants may receive zero points if their response is not worthy of credit according to the grading scheme.
- Where some judgment is required, grading schemes will provide the principles by which points will be awarded and exemplification may be limited.
- Answers outside the specified answering places will not be graded.
- Low writing quality such as unclear texts and structural formulas will not be graded (or penalized for some points).
- Spelling mistakes will not be penalized **EXCEPT** in fill-in-blank questions (one point for each).
- Answers written in Chinese will be graded.

Question Number	Grading Detail	Point Awarded
1	**B is the correct answer** A is incorrect because toluene has the structure of  C is incorrect because aniline has the structure of  D is incorrect because styrene has the structure of 	(1)
2	**A is the correct answer** B is incorrect because ortho position is  C is incorrect because meta position is  D is incorrect because para position is 	(1)

Question Number	Grading Detail	Point Awarded
3	**B is the correct answer** A is incorrect because 15-crown-5 is too big for Li^+ solvation (12-crown-4 is more appropriate) C is incorrect because 15-crown-5 is too small for K^+ solvation (18-crown-6 is more appropriate) D is incorrect because 15-crown-5 is too small for Rb^+ solvation	**(1)**
4	**C is the correct answer** A is incorrect because there are two electrons around the carbon after the heterolysis test, which gives an oxidation number +2 B is incorrect because there are two electrons around the carbon after the heterolysis test, which gives an oxidation number +2 D is incorrect because there are two electrons around the carbon after the heterolysis test, which gives an oxidation number +2	**(1)**
5	**D is the correct answer** A is incorrect because metal-catalyzed reduction prefers to reduce non-polar double bond B is incorrect because hydride reduction only reduces polar double bond C is incorrect because metal-catalyzed reduction prefers to reduce non-polar double bond, while hydride reduction only reduces polar double bond	**(1)**

Question Number	Grading Detail	Point Awarded
6	**D is the correct answer** A is incorrect because hydroxyl usually has a peak at around 3200-3600 cm^{-1} B is incorrect because (primary) amino group usually has two peaks at around 3350-3500 cm^{-1} C is incorrect because carboxyl group usually has a peak at around 2200-3600 cm^{-1}	**(1)**
7	**B is the correct answer** A is incorrect because M–18 is the characteristic peak of alcohol α-cleavage C is incorrect because *x* in (M–*x*) should be an even number for *McLafferty* rearrangement D is incorrect because M–18 is the peak of ^{13}C isotope	**(1)**
8	**A is the correct answer** B is incorrect because tertiary radial is not as stable as allylic radical C is incorrect because vinyl radical is quite unstable (the least stable among choices) D is incorrect because secondary radical is not as stable as allylic radical	**(1)**
9	**B is the correct answer** A is incorrect because quaternary ammonium is a *meta* director C is incorrect because carbonyl group directly linked to the ring is a *meta* director D is incorrect because cyano group is a *meta* director	**(1)**

Question Number	Grading Detail	Point Awarded
10	**D is the correct answer** A is incorrect because "elimination-addition" should not be used B is incorrect because "electron-donating" should not be used C is incorrect because "nucleophilic" should not be used	(1)
11	**B is the correct answer** A is incorrect because protonation is not accomplished C is incorrect because the Grignard reaction can be done only once on each carbonyl group D is incorrect because the Grignard reaction cannot accomplish C–O bond formation	(1)
12	**D is the correct answer** A is incorrect because Lucas' reagent cannot make a C–Zn bond B is incorrect because the leaving group is $ZnCl_2$–OH, but not proton itself C is incorrect because Lucas' reagent cannot make a C–Zn bond	(1)
13	**B is the correct answer** A is incorrect because PCC oxidation cannot change the carbon skeleton C is incorrect because PCC cannot oxidize primary alcohol to carboxylic acid D is incorrect because PCC oxidation cannot change the carbon skeleton	(1)

Question Number	Grading Detail	Point Awarded
14	**A is the correct answer** B is incorrect because Br^- attacks the tertiary site C is incorrect because the ring should be opened D is incorrect because the ring should be opened	(1)
15	**A is the correct answer** B is incorrect because the position that links to a EWG group is not reduced and the position that links to an EDG group is reduced C is incorrect because the position that links to a EWG group is not reduced D is incorrect because the benzene ring is not reduced	(1)
16	**B is the correct answer** A is incorrect because dilute H_2SO_4 is used for desulfonation C is incorrect because H_2SO_4, HNO_3 is the condition of nitration D is incorrect because $AlCl_3$ is not needed for sulfonation	(1)
17	**D is the correct answer** A is incorrect because polyalkylation may occur for Friedel–Crafts alkylation B is incorrect because the carbonyl group is not reduced C is incorrect because polyalkylation may occur for Friedel–Crafts alkylation, and Clemmensen reduction is not needed	(1)

Question Number	Grading Detail	Point Awarded
18	**D is the correct answer** A is incorrect because NaOH cannot protonate $R–O^-$ for quenching the reaction; also, oxidation is needed for converting hydroxyl group to carbonyl group B is incorrect because oxidation is needed for converting hydroxyl group to carbonyl group C is incorrect because NaOH cannot protonate $R–O^-$ for quenching the reaction	**(1)**
19	**B is the correct answer** A is incorrect because the cleavage of ether requires an acidic environment, but Br_2 cannot provide this condition C is incorrect because the cleavage of ether requires Br^- as a nucleophile, but $HBrO_3$ cannot provide this condition D is incorrect because the cleavage of ether requires Br^- as a nucleophile, but $HBrO_4$ cannot provide this condition	**(1)**
20	**B is the correct answer** A is incorrect because elimination-addition needs a high temperature (350°C) for a relatively weak base (NaOH) C is incorrect because the nucleophile should be OH^-, but not NH_2^- D is incorrect because the nucleophile should be OH^-, but not NH_2^-; also, a high temperature is not needed when a strong enough base ($NaNH_2$) is presented	**(1)**

Question Number	Grading Detail	Point Awarded
21	• protecting	(1)
22	• aldehyde	(1)
23	• {dipole moment / polarity}	(1)
24	• electrons (1) • molecular (1)	2
25	• {methyl / CH_3 / Me} (1) • {ethyl / CH_3CH_2 / C_2H_5 / Et} (1)	2

Question Number	Grading Detail	Point Awarded
26	• homotopic **(1)** • enantiotopic **(1)**	2
27	• down **(1)** • up **(1)**	2
28	• bonding	(1)
29	• if a molecule is <u>aromatic</u>, it should have a continuously overlapping *p* orbital system [the first criterion]; the {π / *p*} electron number should be 4*n* + 2 [the second criterion] **(1)** • if the first criterion is met, but the {π / *p*} electron number is 4*n*, the molecule is said to be <u>antiaromatic</u> **(1)** • if the first criterion is not met (not continuously overlapping *p* orbitals), the molecule is said to be <u>nonaromatic</u> **(1)**	3

Question Number	Grading Detail	Point Awarded
30	• $\tilde{\nu} \propto \sqrt{\frac{f}{m_{\text{red}}}}$ (or equivalent explanation of the formula) **(1)** • there are two factors: {force constant / bond strength} and reduced mass **(1)** • (since force constant is the nominator,) wavenumber is directly related to {force constant / bond strength}; an increase in {force constant / bond strength} will cause an increase in wavenumber **(1)** • (since reduced mass is the denominator,) wavenumber is inversely related to reduced mass; an increase in {reduced mass / the mass of atoms on a side of the bond} will cause a decrease in wavenumber **(1)**	**4**
31	• in a strong external magnetic field (B_0), π electrons in {molecules that have continuously overlapping *p* orbitals / aromatic compounds} will move to form a circuit **(1)** • the circuit produces an induced magnetic field, which has an opposite direction inside the ring but a same direction outside the ring **(1)**	**6**

Question Number	Grading Detail	Point Awarded
31 continued	• the net magnetic field inside the ring will be weakened, while the net magnetic field outside the ring will be enhanced **(1)** • (according to Zeeman effect,) when the magnetic flux density increases, the {energy gap / ΔE} between two spin states of the proton will increase, so the rf radiation used for resonance will have a higher frequency (to match the resonance frequency of the proton) **(1)** • the protons outside the ring will experience a greater magnetic flux density, and thus gives a higher resonance frequency; in a NMR spectrum, (because of the higher resonance frequency,) this kind of proton will have a greater {chemical shift / δ (value)}, which leads it to move to downfield **(1)** • the protons inside the ring will experience a smaller magnetic flux density, and thus gives a lower resonance frequency; in a NMR spectrum, (because of the lower resonance frequency,) this kind of proton will have a smaller {chemical shift / δ (value)}, which leads it to move to upfield **(1)**	