Exercise about Eliminations
Wade, Chapter 6, 24 Multiple Choice Questions

Question 1	What is the rate-limiting step of the E1 reaction?
Hint	Review Chapter 6-17 on the E1 reaction.
a.	Homolysis of a C-X bond (X carries a partial negative charge).
Coaching	Incorrect.
b.	Heterolysis of a C-X bond to form a carbanion.
Coaching	Incorrect.
c.	**Heterolysis of a C-X bond to form a carbenium ion.**
Coaching	**CORRECT.**
d.	Heterolysis of a C-X bond to form a carbon radical
Coaching	Incorrect. Heterolysis gives ions.
e.	Homolysis of a C-X bond to form a carbenium ion.
Coaching	Incorrect.

Question 2	Which statement best describes the reaction coordinate diagram of the E1 reaction?
Hint	Review Chapter 6-17 on the E1 reaction.
a.	One-step reaction without transition state.
Coaching	Incorrect.
b.	One-step reaction with 1 transition state.
Coaching	Incorrect.
c.	One-step reaction with 2 transition states.
Coaching	Incorrect.
d.	Two-step process with 1 intermediate and 1 transition state.
Coaching	Incorrect.
e.	**Two-step reaction with 1 intermediate and 2 transition states.**
Coaching	**CORRECT.**

Question 3	Which ordering describes the relative reactivities of the alkyl halides in E1 reactions?
Hint	Review Chapter 6-17 on the E1 reaction.
a.	Benzylic >> allylic >> tertiary > secondary > primary
Coaching	Incorrect.
b.	**Benzylic ≈ allylic > tertiary > secondary > primary**
Coaching	**CORRECT.**
c.	Allylic > benzylic > tertiary > secondary > primary
Coaching	Incorrect. Allyl and beznyl are about the same.
d.	tertiary > benzylic > allylic > secondary > primary
Coaching	Incorrect. Conjugation always beats alkyl substitution.
e.	Benzylic ≈ allylic < tertiary < secondary < primary
Coaching	Incorrect.

Question 4	The E1 reaction of 3-chloro-2-methyl-2-phenylbutane yields 2-methyl-3-phenyl-2-butene in several steps. Which step does **not** belong in the sequence?
Hint	Review Chapter 6-17 on the E1 reaction.
a.	Heterolytic C-Cl dissociation.
Coaching	Incorrect.
b.	Formation of a secondary carbenium ion.
Coaching	Incorrect.
c.	1,2-methyl shift reaction.
Coaching	Incorrect.
d.	Formation of a tertiary benzylic cation.
Coaching	Incorrect.
e.	**Loss of a hydride.**
Coaching	**CORRECT. A proton is lost.**

Question 5	Which rate equation best describes the kinetics of the bimolecular elimination reaction, E2?
Hint	Review Chapter 6-18 on the E2 reaction.
a.	Rate = k [alkyl halide]
Coaching	Incorrect.
b.	Rate = k [alkyl halide]^2
Coaching	Incorrect
c.	**Rate = k [alkyl halide] [base]**
Coaching	**CORRECT.**
d.	Rate = k [alkyl halide]^2 [base]
Coaching	Incorrect.
e.	Rate = k [alkyl halide] [base]^2
Coaching	Incorrect.

Question 6	The E2 reaction is a 1,2-elimination of a proton H^+ and a leaving group Y^-. In the substrate of the E2 reaction, how many σ-bonds are there between the proton and the leaving group?
Hint	Review Chapter 6-18 on the E2 reaction.
a.	1
Coaching	Incorrect.
b.	2
Coaching	Incorrect
c.	**3**
Coaching	**CORRECT.**
d.	4
Coaching	Incorrect.
e.	5
Coaching	Incorrect.

Question 7	The E2 reaction is a 1,2-elimination. Which of the following terms also is used to describe this type of reaction?
Hint	Review Chapter 6-18 on the E2 reaction.
a.	α elimination
Coaching	Incorrect.
b.	β **elimination**
Coaching	**CORRECT.**
c.	γ elimination
Coaching	Incorrect.
d.	δ elimination
Coaching	Incorrect.
e.	ε elimination
Coaching	Incorrect.

Question 8	What is the product of the amide catalyzed HBr elimination reaction from 2,3-dibromobutane?
Hint	Review Chapter 6-18 on the E2 reaction.
a.	butadiene
Coaching	Incorrect. Would require formation of the less substituted alkene in the first E2 reaction.
b.	1-butyne
Coaching	Incorrect. No way.
c.	**2-butyne**
Coaching	**CORRECT.**
d.	Methylallene
Coaching	Incorrect.
e.	This option is not used.
Coaching	Incorrect.

Question 9	How can you prepare 1-butyne from 1-butene?
Hint	Review Chapter 6-18 on the E2 reaction.
a.	(1) Cl_2 / CBr_4 (2) OH^-
Coaching	Incorrect. Step 1 is mixed up, wrong base in double elimination.
b.	(1) Cl_2 / CBr_4 (2) NH_2^-
Coaching	Incorrect. Step 1 is mixed up.
c.	(1) Br_2 / CCl_4 (2) OH^-
Coaching	Incorrect.
d.	**(1) Br_2 / CCl_4 (2) NH_2^-**
Coaching	**CORRECT.**
e.	(1) HBr (2) NH_2^-
Coaching	Incorrect. Generates starting material.

Question 10	Which product(s) are formed in the elimination reaction of 2-bromobutane, $H_3C\text{-}CHBr\text{-}CH_2\text{-}CH_3$, with methoxide,?
Hint	Review Chapter 6-19 on the positional orientation of elimination: The Saytzeff rule.
a.	Only 2-butene, $H_3C\text{-}CH{=}CH\text{-}CH_3$
Coaching	Incorrect.
b.	Only 1-butene, $H_2C{=}CH\text{-}CH_2\text{-}CH_3$
Coaching	Incorrect.
c.	1-butene and 2-butene in equal amounts
Coaching	Incorrect.
d.	More 1-butene than 2-butene
Coaching	Incorrect.
e.	**More 2-butene than 1-butene**
Coaching	**CORRECT.**

Question 11	Imagine the reaction coordinate diagram for the E2 reaction of 2-bromobutane. Which of the statements does **not** apply?
Hint	Review Chapter 6-19 on the positional orientation of elimination: The Saytzeff rule.
a.	There is one path leading to 1-butene and one path leading to 2-butene.
Coaching	Incorrect. This statement is true.
b.	The TS leading to 1-butene and 1-butene both are less stable than the TS leading to 2-butene and 2-butene, respectively.
Coaching	Incorrect. This statement is true.
c.	The transition states are “alkene like.”
Coaching	Incorrect. This is true.
d.	The CC double bond is formed more in the TS for the formation of the 2-butene than in the TS leading to the 1-butene.
Coaching	Incorrect.
e.	**1-butene is formed first and it is then converted into 2-butene.**
Coaching	**CORRECT.**

Question 12	Among the alkyl halides, which one will be the most reactive in the E2 reaction?
Hint	Review Chapter 6-19 on the positional orientation of elimination: The Saytzeff rule.
a.	**$H_3C\text{-}C(CH_3)Br\text{-}CH(CH_3)\text{-}CH_3$**
Coaching	**CORRECT. Forms a tetrasubstituted alkene.**
b.	$H_3C\text{-}C(CH_3)Br\text{-}CH_2\text{-}CH_3$
Coaching	Incorrect. Forms a trisubstituted alkene.
c.	$H_3C\text{-}CHBr\text{-}CH_2\text{-}CH_3$
Coaching	Incorrect. Forms a disubstituted alkene.
d.	$Br\text{-}H_2C\text{-}CH_2\text{-}CH_2\text{-}CH_3$
Coaching	Incorrect. Forms a monosubstituted alkene.
e.	$Br\text{-}H_2C\text{-}CH_3$
Coaching	Incorrect. Forms an unsubstituted alkenes.

Question 13	The E2 reaction of 2-bromo-2,3-dimethylbutane gives mixtures of 2,3-dimethyl-2-butene and 2,3-dimethyl-1-butene. The ratio of these products depends on the choice of base employed. Which base gives the highest yield of 2,3-dimethyl-1-butene?
Hint	Review Chapter 6-19 on the positional orientation of elimination: The Saytzeff rule.
a.	$H_3C-H_2C-O^-$
Coaching	Incorrect. Small base gives Saytzeff product.
b.	$(H_3C)_2HC-O^-$
Coaching	Incorrect. Small base gives Saytzeff product.
c.	$(H_3C)_3C-O^-$
Coaching	Incorrect. Large base gives more of the less substituted product.
d.	$(H_3C)_2(H_3C-H_2C)C-O^-$
Coaching	Incorrect. Large base gives more of the less substituted product.
e.	$\mathbf{(H_3C-H_2C)_3C-O^-}$
Coaching	**CORRECT. Largest base gives most of the less substituted product.**

Question 14	The E2 reaction of 2-bromo-3-methyl-1-phenylbutane with hydroxide results in 3-methyl-1-phenyl-1-butene as the major product. Which one of the following statements explains this regiochemistry?
Hint	Review Chapter 6-19 on the positional orientation of elimination: The Saytzeff rule.
a.	3-methyl-1-phenyl-1-butene is the expected Saytzeff product.
Coaching	Incorrect.
b.	3-methyl-1-phenyl-1-butene is not the Saytzeff product because a very small base was used.
Coaching	Incorrect. Large bases might give regiochemistry that deviates from Saytzeff's rule.
c.	3-methyl-1-phenyl-1-butene is not the Saytzeff product and formed because the product can conjugate with a benzyl group.
Coaching	Incorrect. Benzyl groups are Ph-CH_2-
d.	**3-methyl-1-phenyl-1-butene is not the Saytzeff product and formed because the product can conjugate with a phenyl group.**
Coaching	**CORRECT.**
e.	This option is not used.
Coaching	Incorrect.

Question 15 Which one of the following compounds will react with the highest rate in an E2 reaction?

Hint Review Chapter 6-19 on the positional orientation of elimination: The Saytzeff rule.

a. 3-bromo-1-octene
Coaching Incorrect. This also gives the conjugated product. But the positive charge developed in the TS is not as well delocalized as in the reaction of 4-bromo-1-octene.

b. 4-bromo-1-octene
Coaching CORRECT.

c. 5-bromo-1-octene
Coaching Incorrect. Product is not conjugated.

d. 6-bromo-1-octene
Coaching Incorrect. Product is not conjugated.

e. 7-bromo-1-octene
Coaching Incorrect. Product is not conjugated.

Question 16 What is the <u>minimal</u> structural requirement for HX elimination to occur from H-C-C-X?

Hint Review Chapter 6-20 on the stereochemistry of the E2 reaction.

a. The C-H and C-X bonds must be in the same plane.
Coaching CORRECT. Yes, that's all.

b. The C-H and C-X bonds must be *anti*-periplanar.
Coaching Incorrect. This is the best condition, but periplanarity suffices to afford elimination.

c. The C-H and C-X bonds must be *syn*-periplanar.
Coaching Incorrect. Periplanarity suffices to afford elimination.

d. The C-H and C-X bonds have to be eclipsed.
Coaching Incorrect. True for *syn*-periplanar, but not true for *anti*-periplanar.

e. The C-H and C-X bonds have to be *trans* and staggered.
Coaching Incorrect. True for *anti*-periplanar, but not true for *syn*-periplanar.

Question 17	Which alkene is formed as the major product in E2 reaction of 1-methyl-2-bromohexane?
Hint	Review Chapter 6-19 and 6-20 on the regiochemistry and the stereochemistry of the E2 reaction.
a.	(*E*)-1-methylhex-1-ene
Coaching	Incorrect.
b.	(*E*)-1-methylhex-2-ene
Coaching	Incorrect.
c.	(*E*)-1-methylhex-3-ene
Coaching	Incorrect.
d.	**(*Z*)-1-methylhex-1-ene**
Coaching	**CORRECT.**
e.	(*Z*)-1-methylhex-2-ene
Coaching	Incorrect.

Question 18	Which product is formed in the HBr elimination from (2*S*,3*S*)-2-bromo-3-phenylbutane?
Hint	Review Chapter 6-20 on the stereochemistry of the E2 reaction.
a.	**(*E*)-2-phenyl-2-butene**
Coaching	**CORRECT. Saytzeff product from *anti*-elimination.**
b.	(*Z*)-2-phenyl-2-butene
Coaching	Incorrect. Saytzeff product from *syn*-elimination.
c.	(*E*)-3-methyl-3-phenyl-1-butene
Coaching	Incorrect. Not the Saytzeff product, no geometrical isomers.
d.	(*Z*)-3-methyl-3-phenyl-1-butene
Coaching	Incorrect. Not the Saytzeff product, no geometrical isomers.
e.	This option is not used.
Coaching	Incorrect.

Question 19	Which type of E2 elimination is the only one possible for chlorocyclohexane?
Hint	Review Chapter 6-20 on the stereochemistry of the E2 reaction.
a.	Cl equatorial and *syn*-periplanar elimination
Coaching	Incorrect.
b.	Cl equatorial and *anti*-periplanar elimination
Coaching	Incorrect.
c.	Cl axial and *syn*-periplanar elimination
Coaching	Incorrect.
d.	**Cl axial and *anti*-periplanar elimination**
Coaching	**CORRECT.**
e.	This option is not used.
Coaching	Incorrect.

Question 20	Why does *cis*-1-bromo-4-*tert*.-butylcyclohexane react faster than *trans*-1-bromo-4-*tert*.-butylcyclohexane in E2 reactions?
Hint	Review Chapter 6-20 on the stereochemistry of the E2 reaction.
a.	t-Butyl group equatorial, Br equatorial, allows *syn* elimination
Coaching	Incorrect. Not *cis*.
b.	t-Butyl group equatorial, Br axial, allows *syn* elimination
Coaching	Incorrect. *Syn* elimination not possible.
c.	t-Butyl group equatorial, Br equatorial, allows *anti* elimination
Coaching	Incorrect. Not *cis*.
d.	**t-Butyl group equatorial, Br axial, allows *anti* elimination**
Coaching	**CORRECT.**
e.	This option is not used.
Coaching	Incorrect.

Question 21	Suppose you have a substrate that can react by E1 and by E2. What steps can you take to increase the rate of reaction of the E2 reaction?
Hint	Review Chapter 6-21 on the comparison between the E2 and E1 reactions.
a.	Solvent of higher polarity.
Coaching	Incorrect. Favors E1.
b.	Use weaker base.
Coaching	Incorrect. Favors E1.
c.	**Use higher concentration of the base.**
Coaching	**CORRECT. Base concentration enters the rate expression of the E2 reaction only.**
d.	Use higher temperature.
Coaching	Incorrect. Will speed up both processes.
e.	Use larger base.
Coaching	Incorrect. Slows E2.

Question 22	What is the most likely reaction for a primary halide with a normal (sterically not too demanding) nucleophile/base?
Hint	Review Chapter 6-22 on substitution versus elimination.
a.	E1
Coaching	Incorrect. If a primary halide undergoes elimination, then it will be E2.
b.	SN1
Coaching	Incorrect. If a primary halide undergoes substitution, then it will be SN2.
c.	E2
Coaching	Incorrect. If a primary halide does undergo elimination, then it will be by E2. Yet, E2 only occurs with bulky bases.
d.	**SN2**
Coaching	**CORRECT.**
e.	E1 and SN1
Coaching	Incorrect. Neither of the unimolecular reactions are possible.

Question 23	Which reagents are required to prepare *tert*.-butyl ethyl ether by way of a Williamson ether synthesis?
Hint	Review Chapter 6-22 on substitution versus elimination.
a.	**Ethyl bromide and potassium *tert*.-butoxide**
Coaching	**CORRECT.**
b.	*Tert*.-butyl bromide and potassium ethoxide
Coaching	Incorrect. Gives methylpropene by E1.
c.	*Tert*.-butyl alcohol and potassium ethoxide
Coaching	Incorrect. Alcohols are not substrates in the WES.
d.	Ethylalcohol and potassium *tert*.-butoxide
Coaching	Incorrect. Alcohols are not substrates in the WES.
e.	This option is not used.
Coaching	Incorrect.

Question 24	What is the dihedral angle defined by the leaving group X, the C-atom X is attached to, the *alpha* C-atom and the H-atom attached to the *alpha*-C-atom if the X and the H are “anti-coplanar?”
Hint	Review Glossary to Chapter 6.
a.	0
Coaching	Incorrect.
b.	60
Coaching	Incorrect.
c.	120
Coaching	Incorrect.
d.	150
Coaching	Incorrect.
e.	**180**
Coaching	**CORRECT.**