Unit 2 Review: Answers: Review for Organic Chemistry Unit Test

2. Write the IUPAC names for the following organic molecules:

a) acetone: propanone d) acetylene: ethyne

b) acetic acid: ethanoic acid e) toluene: methyl benzene

c) formic acid: methanoic acid f) isopropyl alcohol: 2-propanol

3. Be able to use physical or chemical properties to distinguish between organic substances. For example, identify one physical or chemical property you could use to distinguish between the following pairs of organic substances:

a) 2-butanol and 2-methyl-2-propanol:

- 2-butanol is a secondary alcohol so it will undergo oxidation reactions with [O] to produce butanone (a ketone). An oxidizing agent such as KMnO₄ or Na₂Cr₂O₇ will change colour to indicate the reaction
- 2-methyl-2-propanol is a tertiary alcohol, so it will not undergo an oxidation reaction with [O]. The oxidizing agent will not change colour

b) cyclopentane and cyclopentene:

- cyclopentane is saturated while cyclopentene is unsaturated
- if bromine in water is added to both compounds, the cyclopentane will not remove the orange colour of the bromine, but the cyclopentene will turn the bromine colourless

c) butane and 1-butanol:

- i) solubility in water: butane is a hydrocarbon so it is non-polar and will not dissolve well in water, while 1-butanol is an alcohol so it is polar and is miscible in water
- ii) state at SATP: butane is a very short chain alkane so it is a gas a SATP. Butanol, because it is polar, is a liquid at SATP
- iii) chemical reactivity: butane is an alkane so it is generally unreactive with most substances. 1-butanol is an alcohol so it will undergo many reactions such as dehydration with a sulfuric acid catalyst, oxidation with an oxidizing agent [O], it will form esters with a carboxylic acid etc.

d) ethanol and 1-decanol:

- ethanol has a very small alkyl group (2 C) so it is completely miscible in water
- 1-decanol has a very long alkyl group (10 C) so it is essentially immiscible in water and it will form an oily layer on top of water

e) butanal and butanone:

- butanal is an aldehyde so it will under oxidation reactions with an oxidizing agent [O]. An oxidizing agent such as KMnO₄ or Na₂Cr₂O₇ will change colour to indicate the reaction
- butanone is a ketone, so it will not undergo an oxidation reaction with [O]. The oxidizing agent will not change colour

f) butanal and butanoic acid:

- i) solubility in water: butanal is an aldehyde so it is not very polar and will not be completely miscible in water, while butanoic acid is a carboxylic acid so it is extremely polar and is very miscible in water
- ii) melting point: butanal is an aldehyde so it is not very polar and will have quite a low melting point. Butanoic acid is a carboxylic acid so it is extremely polar and will have a significantly higher melting point

- iii) chemical reactivity: butanal is an aldehyde so it will under oxidation reactions with an oxidizing agent [O]. An oxidizing agent such as KMnO₄ or Na₂Cr₂O₇ will change colour to indicate the reaction. Butanoic acid is a carboxylic acid so it can not be further oxidized.
- iv) chemical reactivity: butanal is an aldehyde so will not undergo esterification reactions with alcohols. Butanoic acid is a carboxylic acid so it will form esters with alcohols. The formation of an ester can be detected by a change in odour.
- 4. Be able to recognize and predict the products for the following types of reactions:

Type of Reaction	How to Recognize this Type of Reaction
combustion	adding O ₂ (g)
substitution	alkanes and aromatics undergo substitution
addition	requires the presence of a double or triple bond (not benzene ring)
dehydration	requires the presence of both H_2SO_4 and Δ
oxidation	a carbon atom will end up with more bonds to oxygen or fewer bonds to hydrogen
elimination reactions of alcohols	an alcohol is reacted with both H_2SO_4 and Δ
formation of ethers (condensation)	two alcohols react in the presence of both H_2SO_4 and Δ
formation of esters (condensation)	an alcohol and carboxylic acid react in the presence of both H_2SO_4 and Δ
addition polymerization	the monomer contains a C=C double bond

5. Write balanced chemical reactions for the following combustion reactions. Include the states of all reactants and products.

a) 2-butanol: $C_4H_{10}O(l) + 6 O_2(g) \rightarrow 4 CO_2(g) + 5 H_2O(v)$ b) 3-octene: $C_8H_{16}(l) + 12 O_2(g) \rightarrow 8 CO_2(g) + 8 H_2O(v)$ c) cyclopropane: $C_3H_6(g) + 9/2 O_2(g) \rightarrow 3 CO_2(g) + 3 H_2O(v)$ d) phenol: $C_6H_6O(l) + 7 O_2(g) \rightarrow 6 CO_2(g) + 3 H_2O(v)$

Multiple Choice Answers:

Transpic Choice					
1. d	11. b	21. c	31. c	41. c	51. a
2. b	12. c	22. c	32. b	42. d	52. d
3. a	13. a	23. d	33. b	43. b	53. d
4. c	14. c	24. a	34. c	44. a	54. b
5. d	15. c	25. b	35. d	45. b	55. b
6. d	16. d	26. c	36. c	46. d	56. a
7. c	17. b	27. c	37. a	47. a	57. c
8. b	18. a	28. a	38. c	48. a	58. d
9. c	19. c	29. b	39. b	49. c	59. d
10. c	20. a	30. b	40. a	50. d	60. c
					61. c

Identify the family (type) of each organic compound and write its IUPAC name.

- 1. 2-bromo-2-chloro-1,1,1-trifluorethane (alkyl halide)
- 2. 2-butanol (alcohol)
- 3. ethoxy ethane (ether)
- 4. 2-propanol (alcohol)
- 5. 1-bromo-2,2,-dimethylpropane (alkyl halide)
- 6. methyl ethanoate (ester)
- 7. 3-ethyl hexanoic acid (carboxylic acid)
- 8. 4-iodo-1-pentanamine (amine)
- 9. 2-heptanone (ketone)
- 10. tert-butylbenzene (aromatic)
- 11. ethyl butanoate (ester)
- 12. methyl benzoate (ester)
- 13. ethyl ethanoate (ester)
- 14. 2,5-dimethyl-3-hexanone (ketone)
- 15. cis-3-ethyl-2-hexene (alkene)
- 16a) benzamine (amine)
- 16b) ethylcyclohexane (alkane)
- 16c) 2-chlorobenzenol (2-chlorophenol) (alcohol)
- 16d) 3,4-dichlorobenzoic acid (carboxylic acid)
- 16e) 4-methylbenzenol phenol or para-methylphenol (alcohol)
- 17. methyl-3-methylbutanoate (ester)
- 18. 2,5-dimethyl-3-hexanol (alcohol)
- 19. methoxy ethane (ether)
- 20. 2-methyl-2-butanol (tertiary alcohol)
- 21. 5-bromo-2-methyl-2-heptene (alkene)
- 22. 5-chloro-3,4-difluoro-1,3-hexadiene (alkene)
- 23. 2-methoxy-2-methyl propane (ether)
- 24. 2-methyl propene (alkene)
- 25. 4-methyl-1-pentyne (alkyne)
- 26. 3-ethyl-2,7-dimethyloctane (alkane)
- 27. 2-methyl-3-pentanone (ketone)
- 28. 2-chloro cyclohexanamine (its okay if you put in the position number "1", amine)
- 29. 5-ethyl-5-methyl-3-heptanamine (amine)
- 30. 4-methylheptanoic acid (carboxylic acid)
- 31. 2-ethylcyclohexanone (ketone)

Draw the following compounds:

2,3-dichlorobutane CH ₃ - CH - CH - CH ₃ CI CI	cyclohexanol
1-butyne CH ₃ − CH ₂ − C ≡ CH	methoxyethane CH ₃ CH ₂ ————————————————————————————————————
2,3-dibromocyclopentanone —Br —Br	isopropylbenzene H CH3

methylbenzoate OCH3	4-ethyl-2-hexanone $CH_3-CH_2-CH_2-CH_3$ CH_2-CH_3
2-ethylhexanoic acid ${\rm CH_3-\ CH_2-CH_2-CH_2-CH_2-CH-C'}_{\rm CH_3-\ CH_2}$	1,4-dichlorobenzene
2-methylbutanal $ \begin{array}{c} \text{CH}_3-\text{CH}_2-\text{CH}-\text{C}' \\ \text{CH}_3 \end{array} $	2-methyl-2-pentanol OH $CH_3 - CH_2 - CH_2 - CH_3 - CH_3$ CH_3
3-iodocyclooctene	butylpropanoate ${\rm CH_3-CH_2-COO-CH_2-CH_2-CH_2-CH_3}$
1,1-diethylcylopropane CH ₃ - CH ₂ CH ₂ - CH ₃	2-ethoxypropane $ \begin{array}{c} {\rm CH_3-CH_2-O} \\ {\rm CH_3-CH-CH_3} \end{array} $

6. Identify the functional groups in acetominophen (Tylenol), shown to the right. Explain why Tylenol is a solid at SATP.

Functional groups: amine, alcohol, ketone, benzene ring

HO N H Tylenol

Tylenol is a relatively small molecule that contains 3 polar groups, two of which are capable of hydrogen bonding. Because of the strong intermolecular attractions between these functional groups, Tylenol molecules are strongly attracted to one another so they form a solid at SATP.

7. Predict 2 chemical and 2 physical properties of isopropyl alcohol.

Physical properties of isopropyl alcohol:

- polar covalent so it probably has an odour
- has a polar hydroxyl group, so it is a liquid at SATP and its melting point will be relatively high (much higher than for propane)
- it is soluble in water
- it is not an electrolyte

Chemical Properties of isopropyl alcohol:

- it will combust and burn cleanly in oxygen
- it will react with other alcohols to form ethers
- it will react with carboxylic acids to form esters
- it will undergo elimination reactions to form an propene

- because it is a secondary alcohol, it will undergo slow oxidation with an oxidizing agent to form propanone (acetone)
- it can undergo substitution reactions with numerous substances. The hydroxyl group can be replaced by many other functional groups
- 6. Draw the structural formulas for the products of the following reactions (if any). Some reactions will not proceed. Do not balance these reactions or include states. Name the organic products. Classify each reaction as many ways as possible (addition, elimination, dehydration, condensation, oxidation and/or substitution).
- a) This is an addition and a reduction reaction. The product is 2-methyl pentane.

b) This is an oxidation reaction. Because cyclohexanol is a secondary alcohol, the product is cyclohexanone.

c) This is an addition reaction. The product is 2,2,3,3-tetrachloro-4-methyl pentane.

$$\begin{array}{c} \text{CH}_3-\text{CH}-\text{C} \equiv \text{C}-\text{CH}_3 \\ \text{I} \\ \text{CH}_3 \end{array} \begin{array}{c} + \text{Cl}_2\left(g\right) \\ \text{(excess)} \end{array} \longrightarrow \begin{array}{c} \text{CH}_3-\text{CH}-\text{C} \\ \text{I} \\ \text{I} \\ \text{CH}_3 \end{array} \begin{array}{c} \text{CI} \\ \text{CI} \\ \text{CI} \end{array}$$

d) No reaction. There are no products because a tertiary alcohol can not undergo slow oxidation.

$$CH_3$$
 CH_3
 CH_2
 CH_2
 CH_3
 OH
 OH

e) This is an addition reaction; it is also an oxidation reaction. The major product is 3-methyl-3-pentanol. (Markovnikov's rule).

f) This is a substitution reaction. Remember, benzene does not contain double bonds. It is a resonance structure so the bonds are 1 ½ bonds long, so it does not undergo addition reactions. The product is bromobenzene.

$$+$$
 $Br_2(l)$ $\xrightarrow{FeBr_3}$ $+$ HBr

g) This is an oxidation reaction. Aldehydes are oxidized to carboxylic acids. The product is 3-methylbutanoic acid.

h) This is a dehydration or condensation reaction. Two alcohols react to form an ether. The organic product is 1-ethoxy-2-methyl propane.

i) This is a dehydration, condensation or esterification reaction. A carboxylic acid reacts with an alcohol to form an ester. The organic product is ethyl propanoate.

j) This is an addition reaction. It is also an oxidation reaction because the number of C – O bonds is increased. The product is 4-methyl-1,2-cyclohexanediol. (Remember to number in the direction that gives the lowest overall position numbers).

k) This is a dehydration or an elimination reaction. The product is 2-methyl propene.

1) This is a dehydration, condensation or esterification reaction. A carboxylic acid reacts with an alcohol to form an ester. The organic product is butyl ethanoate.

m) This is an addition reaction. The products are 2-chloro-4-methylpentane or 3-chloro-2-methyl pentane.

n) This is a substitution reaction. Replace any of the hydrogen atoms with a bromine atom. One of the possible products is 1-bromopentane.

o) This is a dehydration or elimination reaction. The product is 3-methyl-1-butene.

$$HO - CH_2 - CH_2 - CH_3 - CH_3$$
 CH_3
 $CH_2 = CH - CH_3 + H_2O$
 CH_3
 CH_3

p) There will be no reaction. The carboxylic acid is already oxidized as much as possible.

q) This is a slow oxidation of a primary alcohol. The initial oxidation will produce the aldehyde 3-methyl butanal. The second oxidation will produce the carboxylic acid 3-methylbutanoic acid.

r) This is a substitution reaction. The hydroxyl group is replaced by an amino group. The product is 1-butanamine.

$$\mathsf{CH_3CH_2CH_2CH_2OH} \ + \ \mathsf{NH_3} \ (\mathsf{g}) \qquad \longrightarrow \qquad \mathsf{CH_3CH_2CH_2CH_2NH_2} \ + \ \mathsf{H_2O}$$

s) This is an addition reaction. It is also an oxidation reaction and a test for saturation. The product is 4-methyl-1,2-pentanediol.

t) This is a polymerization reaction. It is also an addition reaction. You don't need to name the polymer.