



1. (2 points) What is the functional group in  $\text{CH}_3\text{COH}$ ?

- 1) alcohol    2) ketone    3) aldehyde    4) carboxylic acid    5) ether

**(3) aldehyde – the trick is to complete the octet around carbon 2. What do you have to do to achieve an octet?**

2. (2 points) What is the functional group in  $\text{CH}_3\text{COOH}$ ?

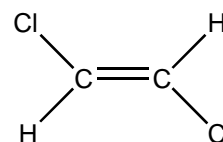
- 1) alcohol    2) ketone    3) aldehyde    4) carboxylic acid    5) ether

**(4) carboxylic acid – the trick is to complete the octet around carbon 2. What do you have to do to achieve an octet?**

3. (2 points) The molecule at right is

- 1) a cis isomer    2) a trans isomer    3) not an isomer

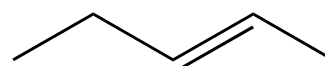
**(2) trans**



4. (2 points) The molecule at right is

- 1) a cis isomer    2) a trans isomer    3) not an isomer

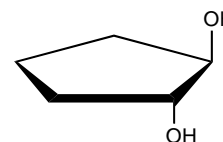
**(2) trans – with respect to the double bond**



5. (2 points) The molecule at right is

- 1) a cis isomer    2) a trans isomer    3) not an isomer

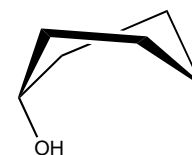
**(2) trans– with respect to the cyclic ring**



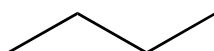
6. (2 points) In the molecule at right the hydroxyl is in what position?

- 1) equatorial    2) axial    3) cis    4) trans

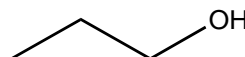
**(2) axial**



7. (2 points) Which molecule below has the highest boiling point?



butane



1-propanol

- 1) butane    2) 1-propanol

**(2) the hydroxyl group of propanol allows for more self-association, so harder to put into gas phase**

For questions 7 through 10, please refer to the molecule at right

8. (2 points) In the molecule above, the ideal bond angle around the 2-carbon is:

1)  $120^\circ$                       2)  $109^\circ$                       3)  $90^\circ$                       4)  $180^\circ$

**(1)  $120^\circ$  It's  $sp^2$  - OWL 12.1a**

9. (2 points) In molecule above, carefully circle all chiral centers. If there are none, write "no chiral centers" next to the drawing.

**(Only) carbon 4 is a chiral center**

10. (2 points) Can the molecule above, as a pure species, participate in intermolecular hydrogen bonding?

1) yes                      2) no

**(1) yes, the OH with itself or with the ketone**

11. (2 points) Which atoms lie in the same plane? Think carefully.

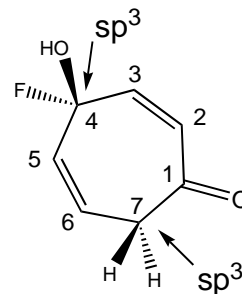
1) carbons 1, 2, 3 only

2) carbons 1, 2, 3, 4 only

3) carbons 1, 2, 3, 4, 7 only

**4) carbons 1, 2, 3, 4, 7, and the O of the carbonyl only**

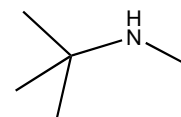
5) all atoms except F and those in OH



12. (2 points) In the molecule at right, the amine is classified as:

1) primary                      2) secondary                      3) tertiary

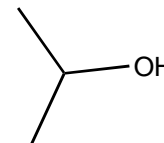
**(2) secondary**



13. (2 points) In the molecule at right, the alcohol is classified as:

1) primary                      2) secondary                      3) tertiary

**(2) secondary**



14. (2 points) Which is the weaker acid?

1) cyclohexanol                      2) phenol                      3) they are the same

**(1) alcohols are terrible acids, except for phenol. Because of resonance, phenol can delocalize the charge on the deprotonated species. Cyclohexanol cannot.**

15. (2 points) Aldehydes are readily oxidized (by oxygen in air) to
- 1) ketones
  - 2) alcohols
  - 3) carboxylic acids
  - 4) the parent alkanes
  - 5) aldehydes are not readily oxidized

**(3) carboxylic acids – see Chapter 17.4.a. Note that the C adopts a higher oxidation number in the carboxylic acid. H is replaced by OH**

16. (2 points) Ketones are readily oxidized (by oxygen in air) to
- 1) aldehydes
  - 2) alcohols
  - 3) carboxylic acids
  - 4) the parent alkanes
  - 5) ketones are not readily oxidized

**(5) not readily oxidized – see Chapter 17.4.a. OH does not readily replace an alkane off of the ketone.**

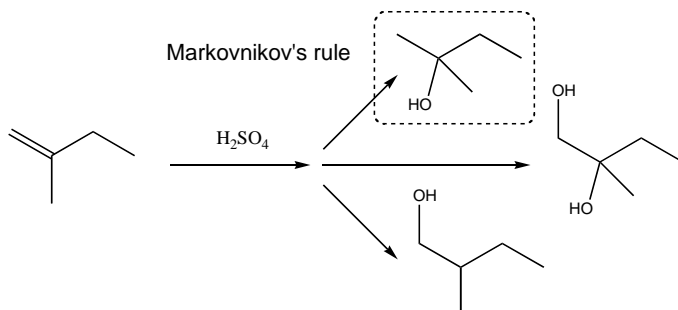
17. (2 points) Aldehydes are reduced by  $H_2$  and an appropriate catalyst to
- 1) ketones
  - 2) alcohols
  - 3) carboxylic acids
  - 4) the parent alkanes
  - 5) aldehydes are not readily reduced

**(2) alcohols – see Chapter 17.4.b. Note that the C adopts a lower oxidation number in the alcohol. You can see that  $H_2$  is “added” across the  $C=O$  bond**

18. (2 points) Ketones are reduced by  $H_2$  and an appropriate catalyst to
- 1) ketones
  - 2) alcohols
  - 3) carboxylic acids
  - 4) the parent alkanes
  - 5) ketones are not readily reduced

**(2) alcohols – see Chapter 17.4.b. Note that the C adopts a lower oxidation number in the alcohol. You can see that  $H_2$  is “added” across the  $C=O$  bond**

19. (2 points) Circle the correct reaction product:



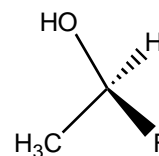
20. (2 points) A racemic mixture
- 1) rotates polarized light to the right
  - 2) rotates polarized light to the left
  - 3) does not rotate polarized light

**(3) half the molecules rotate light to the right, while the other half rotates it to the left, so the mixture has no net rotation.**

21. (2 points) The molecule at right is which enantiomer?

- 1) R
- 2) S

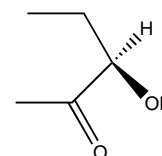
**(2) S**



22. (2 points) The molecule at right is which enantiomer?

- 1) R
- 2) S

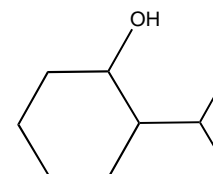
**(1) R**



23. How many stereoisomers are possible for the molecule at right?

Answer: 4

**There are 2 stereocenters, so there are  $2^2 = 4$  stereoisomers**



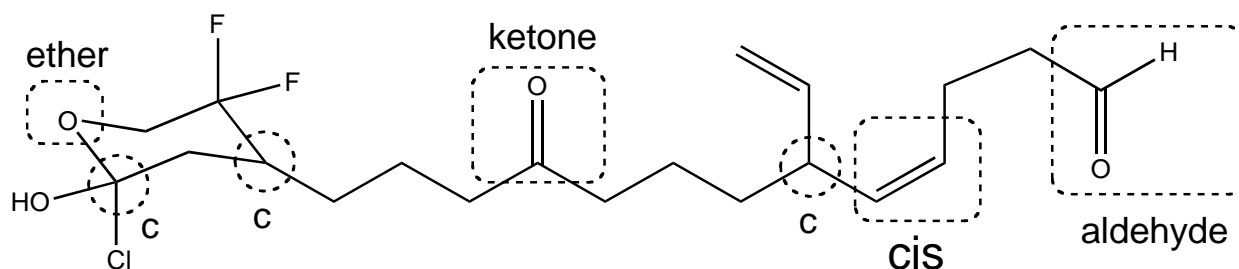
Use the choices below for each of the questions xx through yy

- 1)  $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_2\text{CH}_3)\text{CH}_2\text{CH}_2\text{CH}_3$
  - 2)  $\text{CH}_3\text{CH}_2\text{COOCH}_2\text{CH}_2\text{CH}_3$
  - 3)  $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_2\text{CH}_3$
  - 4)  $\text{CH}_3\text{CH}_2\text{CHOHCH}_2\text{CH}_2\text{CH}_3$
  - 5)  $\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_2\text{CH}_3$
24. (2 points) Which of the above has an ether functional group? \_\_\_\_ **(5)**
25. (2 points) Which of the above has a ketone functional group? \_\_\_\_ **(3)**
26. (2 points) Which of the above has an ester functional group? \_\_\_\_ **(2)**

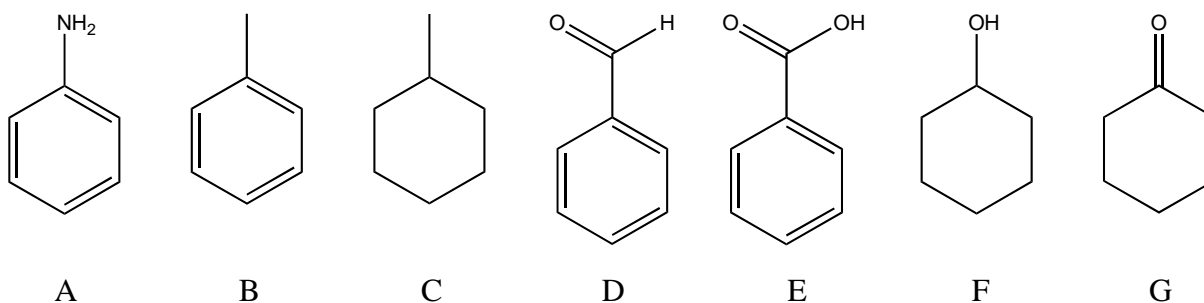
27. (2 points) In which of the above pure compounds would intermolecular H-bonding interactions be expected to have an effect on boiling point?

**(4) the hydroxyl group has the largest potential of H-bonding and, in particular, has both donor and acceptor capability – OWL 14.6**

For questions 28 to 32, refer to the molecule below. Please mark your answers neatly.



28. (2 points) Circle an **aldehyde** functional group and clearly write “**A**” next to it.
29. (2 points) Circle a **ketone** functional group and clearly write “**K**” next to it.
30. (2 points) Circle an **ether** functional group and clearly write “**E**” next to it.
31. (2 points) Circle each **chiral center** and clearly write “**C**” next to each.
32. (2 points) Circle a **cis bond** and clearly write “**cis**” next to it.



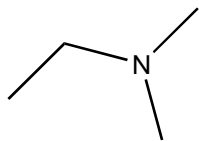
33-39. (2 points each) Place the letter for each molecule above next to its correct name below.

- |                    |                          |                              |
|--------------------|--------------------------|------------------------------|
| <b>B</b> _ toluene | <b>E</b> _ benzoic acid  | <b>C</b> _ methylcyclohexane |
| ___ phenol         | <b>D</b> _ benzaldehyde  | <b>F</b> _ cyclohexanol      |
| <b>A</b> _ aniline | ___ cyclohexanoic acid   | ___ cyclohexylamine          |
| ___ cyclohexanal   | <b>G</b> _ cyclohexanone |                              |

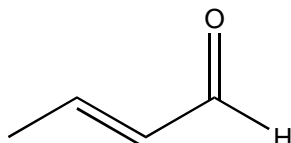
For the following, refer to the structures above and reply with the corresponding letter (A-G).

40. (2 points) Which molecule above in a reaction with  $K_2Cr_2O_7$  and  $H_2SO_4$  yields benzoic acid? **\_\_D\_\_**
41. (2 points) Which molecule above in a reaction with  $H_2$  and a transition metal catalyst yields cyclohexanol? **\_\_G\_\_**
42. (2 points) Which molecule above in a reaction with  $K_2Cr_2O_7$  and  $H_2SO_4$  yields cyclohexanone? **\_\_F\_\_**

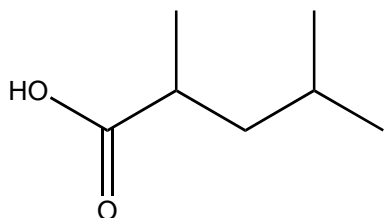
43. (4 points) Draw the structure for dimethylethylamine:



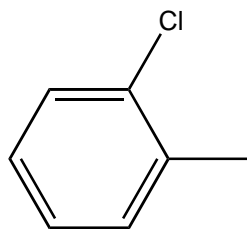
44. (4 points) Draw the structure for 2-butenal:



45. (4 points) Draw the structure for 2,4-dimethylpentanoic acid



46. (4 points) Draw the structure for ortho-chlorotoluene



**Chem 250 Bonus Question****Evening Exam 1**

Elena loves her horse (she likes everything with four legs and a tail). One day her horse becomes terribly ill. The vet diagnoses a bacterial infection and prescribes a course of antibiotics. Unfortunately, the antibiotics cost \$1,000 per week and Elena doesn't have that kind of money. The vet gives her a free sample he obtained from a salesman, but that's only good for 3 days. She gives that to her horse and he starts to improve, but it will take 3 weeks of treatment.

Her friend Bob says he can get the same antibiotic for \$20/week via the internet ([www.crackpotdrugs.com](http://www.crackpotdrugs.com)), so they order some. In the mean time, Elena worries "how do we know this is the real thing?" So when the internet antibiotic arrives she takes some of it and some of the free sample and gives them to her friend Sharon, who works in a chemistry lab. Sharon runs elemental analysis and mass spec and tells Elena that both samples show the same composition and bond connectivity – and they both match up with what is expected for the structure of the antibiotic.

Elena gives the new drug to her horse, who immediately takes a turn for the worse.

(2 points) What's happening? Why do you think the horse took a turn for the worse?

**Most likely, the antibiotic is active as one stereoisomer (eg, R or S), but toxic as the other isomer (this does happen). Synthesizing or purifying just the one active isomer is often a very expensive part of drug manufacturing (after all, the compounds have the exact same chemical properties and so are difficult to isolate), so it would make sense that "crackpotdrugs" could sell a racemic mixture for much less money than the drug company can sell the active isomer. The horse, of course, can tell the difference between R and S since he is chiral.**

(2 points) Had Elena taken Chem 250, she might have asked for one more test that could have warned her about a potential problem. Describe that test.

**She could have asked the chemist to use a polarimeter to measure the extent to which the compounds rotate plane polarized light. The racemic mixture would not rotate light, while the correct isomer will rotate light in a specific direction.**

**Most of you figured that the internet site sold her the *wrong* isomer. This is possible, and I gave full credit for that answer, but it's much more likely that they could purchase the racemic mixture and sell that for cheap.**