

|          |     |     |     |     |      |       |
|----------|-----|-----|-----|-----|------|-------|
| Question | 1-2 | 3-5 | 6-7 | 8   | 9-11 | Total |
| Mark     | /21 | /20 | /12 | /15 | /22  | /90   |

## CHEMISTRY 112 TEST

Tuesday 9 September 2006

Name (Print Clearly): .....

Student ID number: .....

Signature: .....

### Instructions:

Attempt **all** questions. Enter answers in the spaces provided.

Total marks: 90

Time allowed: 90 minutes

### *Question 1 (6 marks)*

A compound was found to have an exact mass of 102.0702 from its mass spectrum, peaks at 3500 and 1705  $\text{cm}^{-1}$  in its infrared spectrum, and 4 peaks in its  $^{13}\text{C}$  NMR spectrum.

Using data from the tables below, give:

(a) the molecular formula of the compound                      Ans:

(b) the most likely functional group(s) present                      Ans:

(c) a possible structure for the compound                      Ans:

*Table of calculated masses*

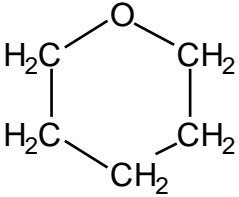
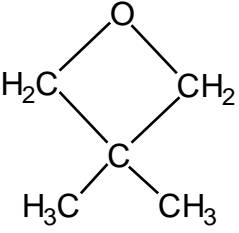
|          |   |
|----------|---|
| 102.0218 | $\text{C}_6\text{H}_2\text{N}_2$            |
| 102.0344 | $\text{C}_7\text{H}_4\text{N}$              |
| 102.0555 | $\text{C}_4\text{H}_8\text{NO}_2$           |
| 102.0681 | $\text{C}_5\text{H}_{10}\text{O}_2$         |
| 102.0793 | $\text{C}_4\text{H}_{10}\text{N}_2\text{O}$ |
| 102.0919 | $\text{C}_5\text{H}_{12}\text{NO}$          |
| 102.1045 | $\text{C}_6\text{H}_{14}\text{O}$           |
| 102.1157 | $\text{C}_5\text{H}_{14}\text{N}_2$         |

*Table of infrared absorption frequencies*

|     |                            |
|-----|----------------------------|
| O-H | 3200-3650 $\text{cm}^{-1}$ |
| N-H | 3300-3500 $\text{cm}^{-1}$ |
| C-O | 970-1260 $\text{cm}^{-1}$  |
| C=O | 1645-1765 $\text{cm}^{-1}$ |
| C-N | 1000-1400 $\text{cm}^{-1}$ |
| C=N | 1625-1725 $\text{cm}^{-1}$ |

**Question 2** (15 marks)

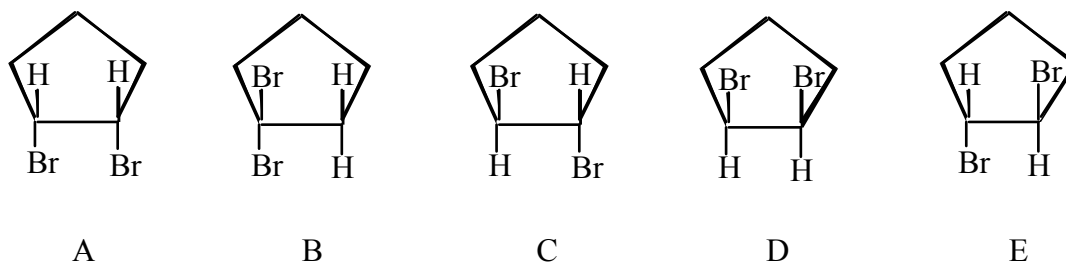
Complete the following table, showing the number of peaks expected in the  $^{13}\text{C}$  and  $^1\text{H}$  NMR spectra for each of the isomers of  $\text{C}_5\text{H}_{10}\text{O}$ . Also give the relative integrals for the peaks in the  $^1\text{H}$  NMR spectrum for each compound.

|   | $^{13}\text{C}$ | $^1\text{H}$ | relative integrals ( $^1\text{H}$ ) |
|---|-----------------|--------------|-------------------------------------|
| $\text{CH}_3\text{CH}_2\overset{\text{O}}{\parallel}{\text{C}}\text{CH}_2\text{CH}_3$ |                 |              |                                     |
|      |                 |              |                                     |
|     |                 |              |                                     |
| $\text{CH}_3\overset{\text{O}}{\parallel}{\text{C}}\text{CH}_2\text{CH}_2\text{CH}_3$ |                 |              |                                     |

Where it is not possible to distinguish between any two isomers based on the data you have entered into the table, describe how you could use another spectroscopic technique to make the distinction.

**Question 3** (8 marks)


Shown below are the structures (A – E) of several dibromocyclopentanes



List two which are:

- |                            |      |
|----------------------------|------|
| (a) constitutional isomers | Ans: |
| (b) enantiomers            | Ans: |
| (c) diastereoisomers       | Ans: |
| (d) identical              | Ans: |

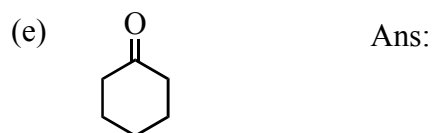
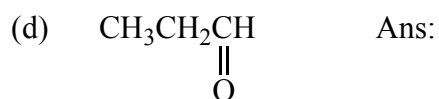
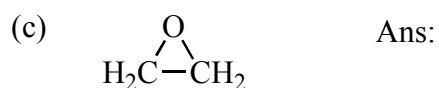
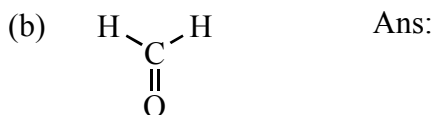
Compound D is a *meso* compound. What does this term mean?

Which of the structures (A – E) would be formed from the reaction of cyclopentene  with bromine?                      Ans:



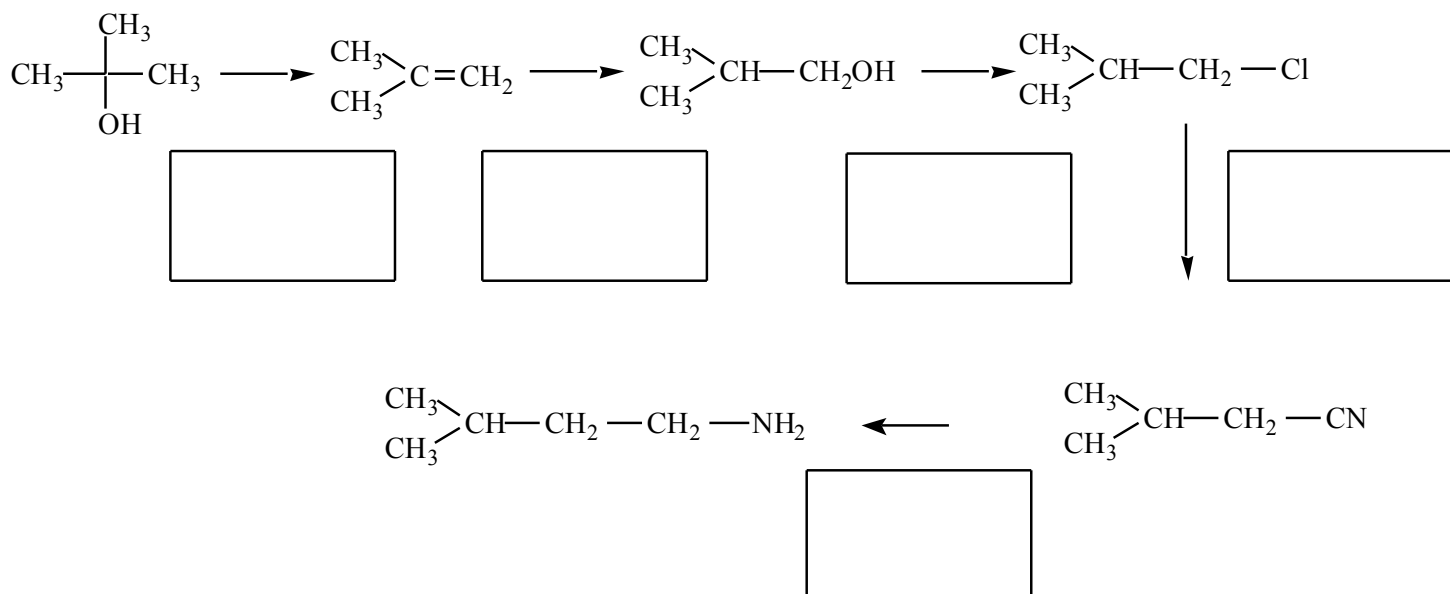
**Question 6** (5 marks)

Draw the structures of the organic products of the reaction of ethylmagnesium bromide ( $\text{CH}_3\text{CH}_2\text{MgBr}$ ) with each of the following compounds, after subsequent treatment with aqueous acid:



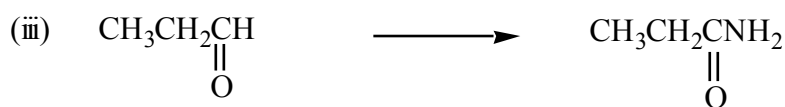
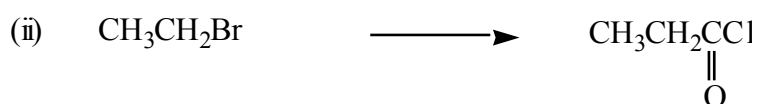
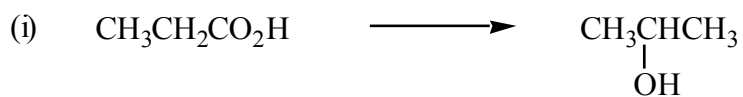
**Question 7** (7 marks)

For the reaction sequence shown below write the missing reagents in the boxes provided.



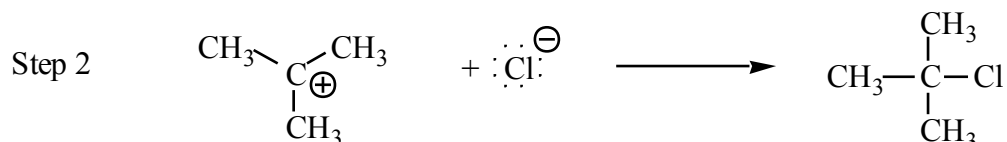
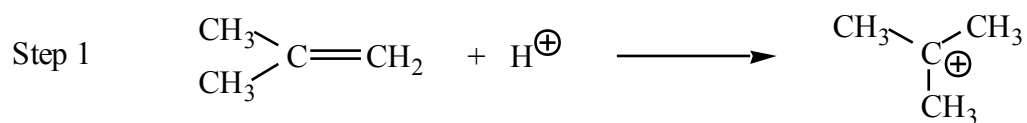
**Question 8** (15 marks)

For each of the following transformations draw a reaction scheme that could be used to convert the starting material to the final product. For each step of the reaction sequence specify all necessary reagents and reaction conditions.



**Question 9** (8 marks)

Shown below is the mechanism for the electrophilic addition of HCl to methylpropene.

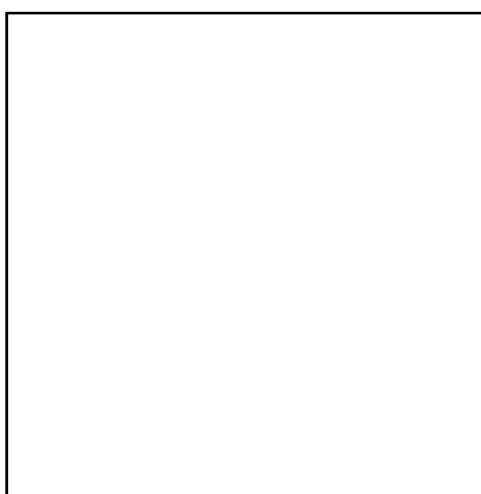
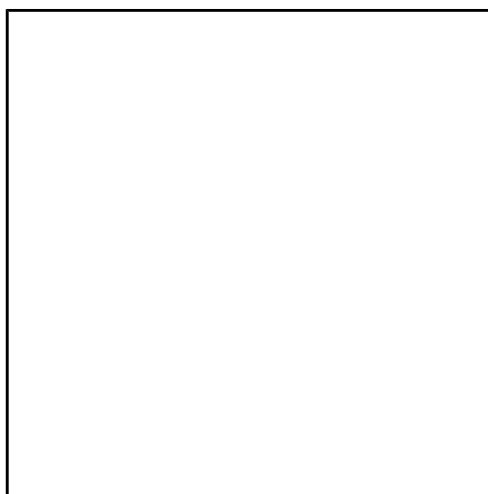
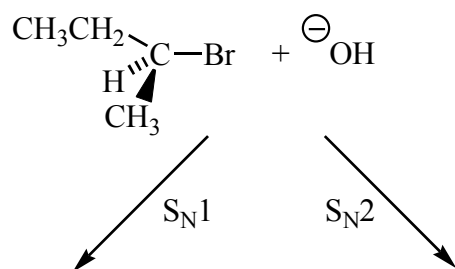


- (a) For each step above draw an arrow to indicate the movement of electrons.
- (b) Which step of the mechanism is the rate determining step?      Ans:
- (c) In Step 1, which species is the electrophile?      Ans:
- (d) In Step 2, which species is the nucleophile?      Ans:
- (e) In Step 1, the  $\text{H}^{\oplus}$  becomes bonded to the terminal carbon rather than the central carbon, in accordance with Markovnikov's Rule. Explain the reason for this.

Ans:

**Question 10** (6 marks)

The optically active alkyl halide shown below can undergo nucleophilic substitution with hydroxide ion by both S<sub>N</sub>1 and S<sub>N</sub>2 reaction mechanisms. In the boxes provided draw the structure(s) of the product(s) formed for each mechanism.



Describe two ways that could be used to distinguish experimentally which mechanism is operating.

Ans:

**Question 11** (8 marks)

Draw the mechanism for the addition of bromine to propene.

What additional product(s) would be formed if the above reaction were carried out in the presence of sodium chloride?

Ans: