Q1. Propene reacts with hydrogen bromide to form a mixture of saturated organic products. The proton n.m.r. spectrum of the major organic product has

A 3 peaks with relative intensities 3 : 2 : 2

B 2 peaks with relative intensities 3 : 4

C 3 peaks with relative intensities 3 : 1 : 3

D 2 peaks with relative intensities 6 : 1

(Total 1 mark)

Q2. Hydrogen and carbon monoxide were mixed in a 2:1 mole ratio. The mixture was allowed to reach equilibrium according to the following equation at a fixed temperature and a total pressure of 1.75×10^4 kPa.

$$2H_2(g) + CO(g) \rightleftharpoons CH_3OH(g)$$

(a) The equilibrium mixture contained 0.430 mol of carbon monoxide and 0.0850 mol of methanol.

(i) Calculate the number of moles of hydrogen present in the equilibrium mixture.

.....

(ii) Hence calculate the mole fraction of hydrogen in the equilibrium mixture.

.....

.....

.....

(iii) Calculate the partial pressure of hydrogen in the equilibrium mixture.

.....

.....

.....

(5)

(b) In a different mixture of the three gases at equilibrium, the partial pressure of carbon monoxide was 7550 kPa, the partial pressure of hydrogen was 12300 kPa and the partial pressure of methanol was 2710 kPa.

(i) Write an expression for the equilibrium constant, K_p, for this reaction.

.....

(ii) Calculate the value of the equilibrium constant, K_p, for the reaction under these conditions and state its units.

K_p .....

.....

Units .....

(3)

(c) Two isomeric esters **E** and **F** formed from methanol have the molecular formula $C_6H_{12}O_2$

Isomer **E** has only 2 singlet peaks in its proton n.m.r. spectrum.

Isomer **F** is optically active.

Draw the structures of these two isomers.

*Isomer **E***

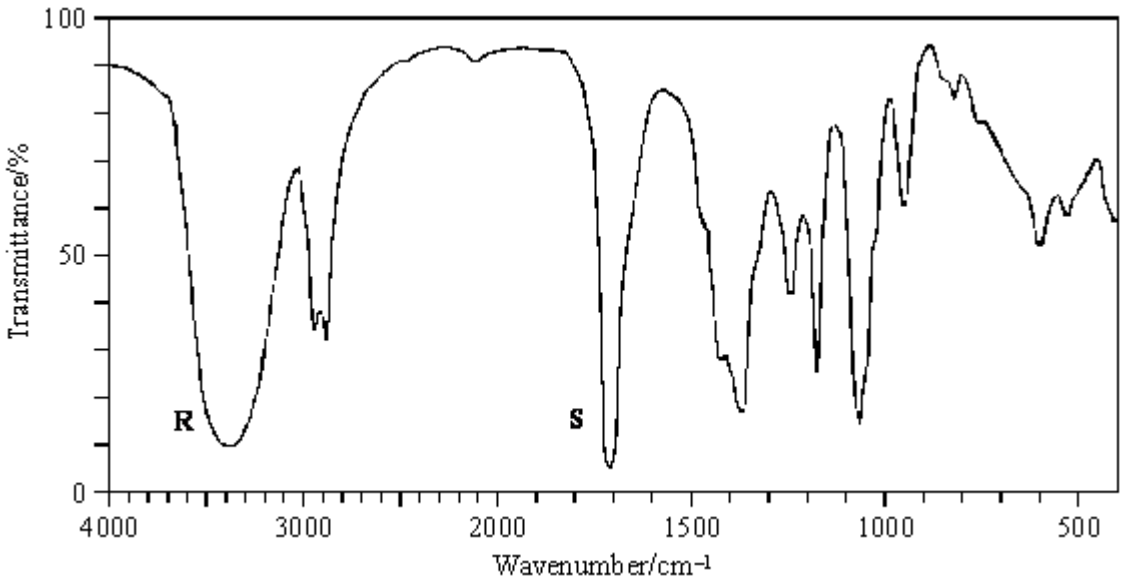
*Isomer **F***

(2)
(Total 10 marks)

Q3. Spectral data for use in this question are provided below the Periodic Table (first item on the database).

Compound **Q** has the molecular formula $C_4H_8O_2$

(a) The infra-red spectrum of **Q** is shown below.



Identify the type of bond causing the absorption labelled **R** and that causing the absorption labelled **S**.

R .....

S .....

(2)

(b) **Q** does not react with Tollens' reagent or Fehling's solution. Identify a functional group which would react with these reagents and therefore cannot be present in **Q**.

.....

(1)

(c) Proton n.m.r. spectra are recorded using a solution of a substance to which tetramethylsilane (TMS) has been added.

(i) Give two reasons why TMS is a suitable standard.

Reason 1 .....

Reason 2 .....

(ii) Give an example of a solvent which is suitable for use in recording an n.m.r. spectrum. Give a reason for your choice.

Solvent .....

Reason .....

(4)

(d) The proton n.m.r. spectrum of **Q** shows 4 peaks.

The table below gives δ values for each of these peaks together with their splitting patterns and integration values.

δ/ppm	2.20	2.69	3.40	3.84
Splitting pattern	singlet	triplet	singlet	triplet
Integration value	3	2	1	2

What can be deduced about the structure of **Q** from the presence of the following in its n.m.r. spectrum?

(i) The singlet peak at δ = 2.20

.....

(ii) The singlet peak at δ = 3.40

.....

(iii) Two triplet peaks

.....

(3)

(e) Using your answers to parts (a), (b) and (d), deduce the structure of compound **Q**.

(1)
(Total 11 marks)

Q4. How many peaks will be observed in the low-resolution proton n.m.r. spectrum of $(CH_3)_2CHCOO(CH_2)_3CH_3$?

A 4

B 5

C 6

D 7

(Total 1 mark)