



## Chapter 11 -3 - SL Question set 1

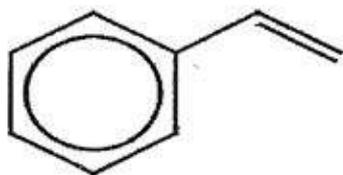
1. [1 mark]

What is the Index of Hydrogen Deficiency (IHD) for 1,3,5-hexatriene ( $C_6H_8$ )?

- A. 1
- B. 3
- C. 5
- D. 6

2. [1 mark]

What is the degree of unsaturation (index of hydrogen deficiency) for the molecule?



- A. 1
- B. 2
- C. 4
- D. 5

3. [1 mark]

What can be determined about a molecule from the number of signals in its  $^1H$  NMR spectrum?

- A. Bonds present
- B. Molecular formula
- C. Molecular mass
- D. Number of hydrogen environments



4. [1 mark]

What can be deduced from the infrared (IR) spectrum of a compound?

- A. Number of hydrogens
- B. Number of hydrogen environments
- C. Bonds present
- D. Molar mass

5. [1 mark]

What information is provided by  $^1\text{H}$  NMR, MS and IR for an organic compound?

- I.  $^1\text{H}$  NMR: chemical environment(s) of protons
- II. MS: fragmentation pattern
- III. IR: types of functional group

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

6. [1 mark]

What can be deduced from the infrared (IR) spectrum of a compound?

- A. Number of hydrogens
- B. Number of hydrogen environments
- C. Bonds present
- D. Molar mass



7. [1 mark]

Which technique involves breaking covalent bonds when carried out on an organic compound?

- A. infrared spectroscopy
- B. nuclear magnetic resonance spectroscopy
- C. X-ray crystallography
- D. mass spectrometry

8. [1 mark]

Which is correct for the spectra of organic compounds?

- A. Mass spectroscopy provides information about bond vibrations.
- B.  $^1\text{H}$  NMR spectroscopy provides the values of carbon-hydrogen bond lengths.
- C. Infrared spectroscopy provides the number of hydrogen atoms.
- D. Mass spectroscopy provides information about the structure.

9. [1 mark]

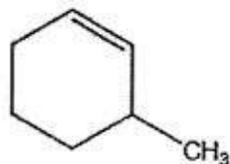
What is the ratio of areas under each signal in the  $^1\text{H}$  NMR spectrum of 2-methylbutane?

- A. 6 : 1 : 2 : 3
- B. 3 : 3 : 1 : 5
- C. 6 : 1 : 5
- D. 3 : 3 : 1 : 2 : 3



10. [1 mark]

What is the index of hydrogen deficiency, IHD, of 3-methylcyclohexene?



- A. 0
- B. 1
- C. 2
- D. 3

11. [1 mark]

What is the ratio of the areas of the signals in the  $^1\text{H}$  NMR spectrum of pentan-3-ol?

- A. 6:4:1:1
- B. 6:2:2:2
- C. 5:5:1:1
- D. 3:3:2:2:1:1

12. [1 mark]

Which feature of a molecule does infrared spectrometry detect?

- A. molecular mass
- B. bonds present
- C. total number of protons
- D. total number of proton environments



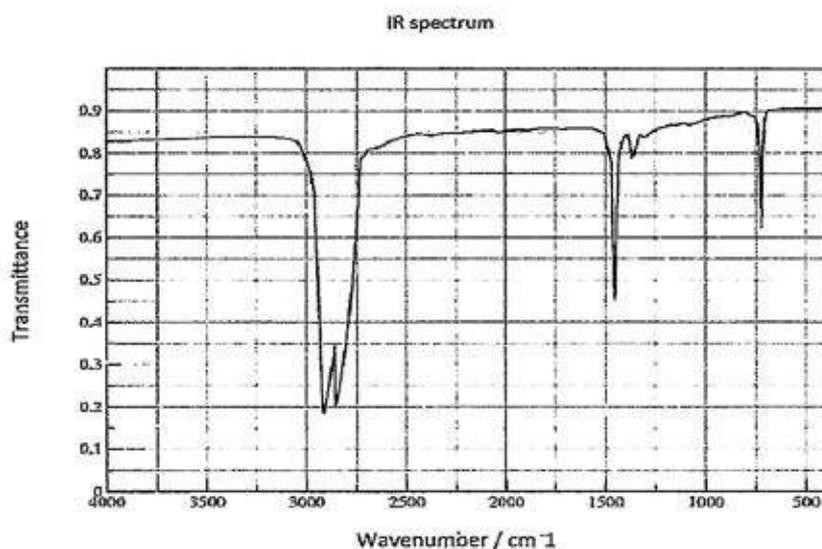
13a. [2 marks]

Polymers have a wide variety of uses but their disposal can be problematic.

Draw a section of isotactic polychloroethene (polyvinylchloride, PVC) showing all the atoms and all the bonds of four monomer units.

13b. [1 mark]

The infrared (IR) spectrum of polyethene is given.



[Source: used with kind permission from Dr Aubrey Jaffer]

Suggest how the IR spectrum of polychloroethene would differ, using section 26 of the data booklet.

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13c. [2 marks]

Explain how plasticizers affect the properties of plastics.

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13d. [1 mark]

Suggest why the addition of plasticizers is controversial.

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13e. [1 mark]

Outline, giving a reason, how addition and condensation polymerization compare with regard to green chemistry.

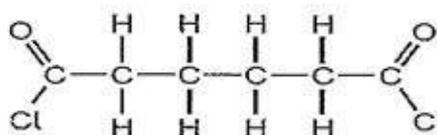
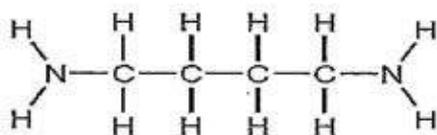
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13f. [1 mark]

Draw the full structural formula of the organic functional group formed during the polymerization of the two reactants below.





**14a. [1 mark]**

Ethyne,  $C_2H_2$ , reacts with oxygen in welding torches.

Write an equation for the complete combustion of ethyne.

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**14b. [1 mark]**

Deduce the Lewis (electron dot) structure of ethyne.

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**14c. [1 mark]**

Compare, giving a reason, the length of the bond between the carbon atoms in ethyne with that in ethane,  $C_2H_6$ .

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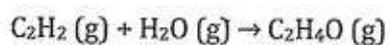
14d. [1 mark]

Identify the type of interaction that must be overcome when liquid ethyne vaporizes.

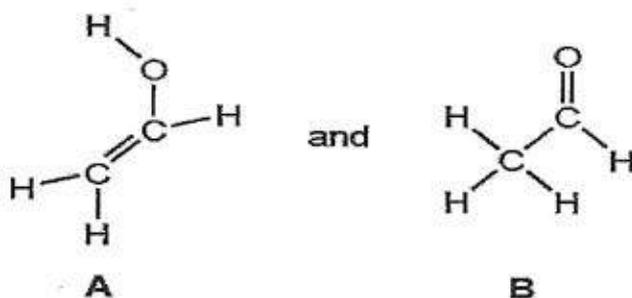
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14e. [1 mark]

Ethyne reacts with steam.



Two possible products are:



Product A contains a carbon-carbon double bond. State the type of reactions that compounds containing this bond are likely to undergo.

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14f. [1 mark]

State the name of product B, applying IUPAC rules.

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14g. [3 marks]

Determine the enthalpy change for the reaction, in kJ, to produce **A** using section 11 of the data booklet.

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14h. [1 mark]

The enthalpy change for the reaction to produce **B** is  $-213$  kJ. Predict, giving a reason, which product is the most stable.

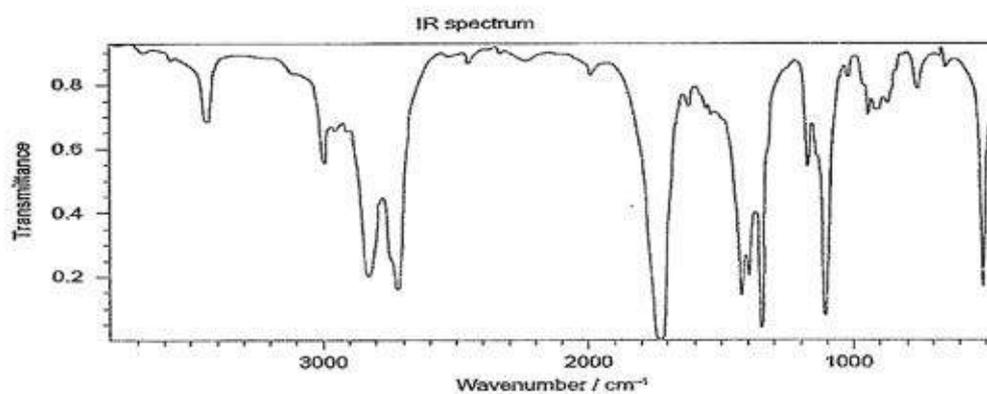
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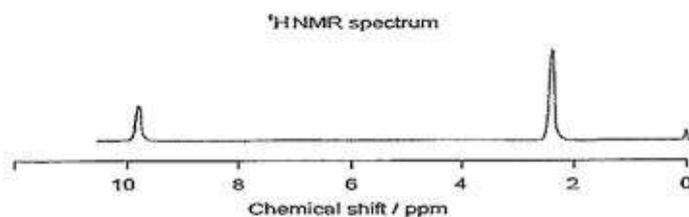
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14i. [2 marks]

The IR spectrum and low resolution  $^1\text{H}$  NMR spectrum of the actual product formed are shown.



[Source: NIST Chemistry WebBook SRD 69  
<https://webbook.nist.gov/chemistry/> DOI: <https://doi.org/10.18434/T4D303>  
<http://webbook.nist.gov/cgi/inchi?Spec=C75070&Index=2&Type=IR>  
Acetaldehyde: Data compiled by: Colclough Society, Inc.]





Deduce whether the product is **A** or **B**, using evidence from these spectra together with sections 26 and 27 of the data booklet.

Identity of product:

One piece of evidence from IR:

One piece of evidence from  $^1\text{H}$  NMR:

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**14j.** [2 marks]

Product **B**,  $\text{CH}_3\text{CHO}$ , can also be synthesized from ethanol.

Suggest the reagents and conditions required to ensure a good yield of product **B**.

Reagents:

Conditions:

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14k. [1 mark]

Deduce the average oxidation state of carbon in product B.

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14l. [3 marks]

Explain why product B is water soluble.

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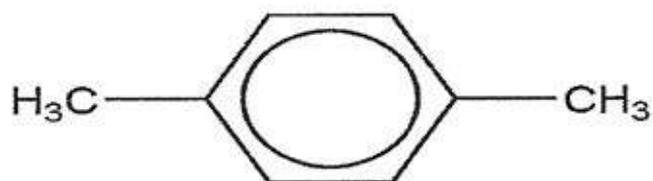
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15a. [2 marks]

Xylene is a derivative of benzene. One isomer is 1,4-dimethylbenzene.



State the number of  $^1\text{H}$  NMR signals for this isomer of xylene and the ratio in which they appear.

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**15b. [1 mark]**

Draw the structure of one other isomer of xylene which retains the benzene ring.

**15c. [1 mark]**

Xylene, like benzene, can be nitrated.

Write the equation for the production of the active nitrating agent from concentrated sulfuric and nitric acids.

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**15d. [4 marks]**

Explain the mechanism for the nitration of benzene, using curly arrows to indicate the movement of electron pairs.

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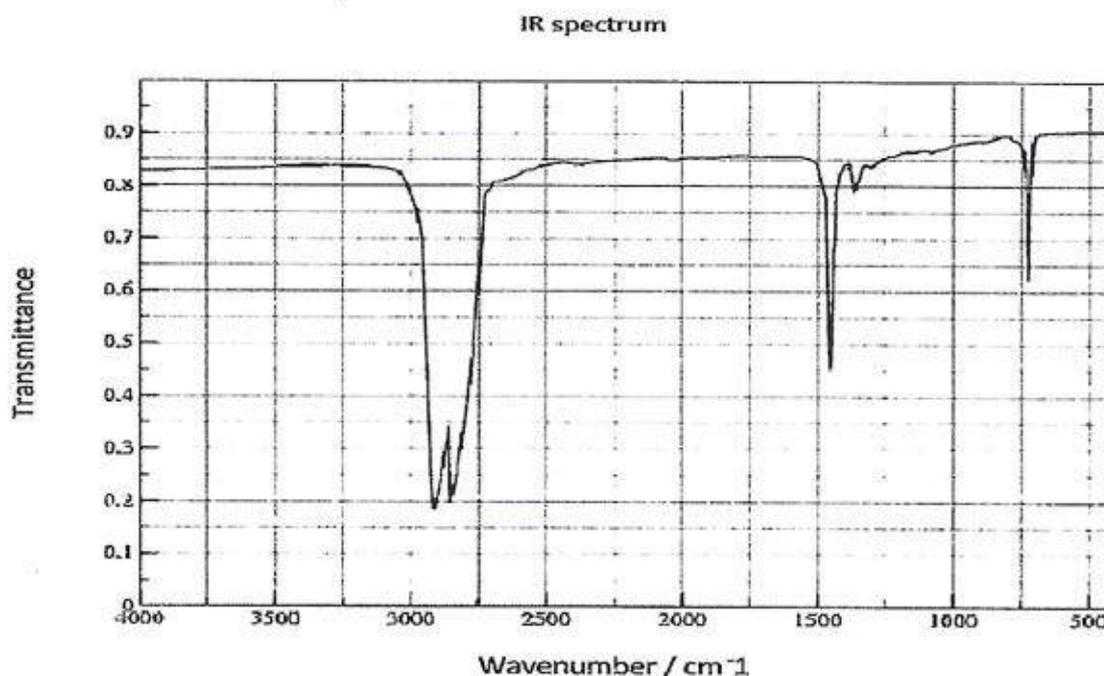
16a. [2 marks]

Polymers have a wide variety of uses but their disposal can be problematic.

Draw a section of isotactic polychloroethene (polyvinylchloride, PVC) showing all the atoms and all the bonds of **four** monomer units.

16b. [1 mark]

The infrared (IR) spectrum of polyethene is given.



[Source: used with kind permission from Dr Aubrey Jaffer]

Suggest how the IR spectrum of polychloroethene would differ, using section 26 of the data booklet.



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**16c. [1 mark]**

Identify a hazardous product of the incineration of polychloroethene.

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**16d. [2 marks]**

Explain how plasticizers affect the properties of plastics.

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**16e. [1 mark]**

Suggest why the addition of plasticizers is controversial.

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17a. [2 marks]

Urea,  $(\text{H}_2\text{N})_2\text{CO}$ , is excreted by mammals and can be used as a fertilizer.

Calculate the percentage by mass of nitrogen in urea to two decimal places using section 6 of the data booklet.

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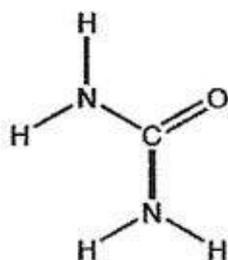
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17b. [1 mark]

Suggest how the percentage of nitrogen affects the cost of transport of fertilizers giving a reason.

17c. [3 marks]

The structural formula of urea is shown.



Predict the electron domain and molecular geometries at the nitrogen and carbon atoms, applying the VSEPR theory.

	Electron domain geometry	Molecular geometry
Nitrogen	.....	.....
Carbon	.....	trigonal planar



**17d. [2 marks]**

Urea can be made by reacting potassium cyanate, KNCO, with ammonium chloride, NH<sub>4</sub>Cl.



Determine the maximum mass of urea that could be formed from 50.0 cm<sup>3</sup> of 0.100 mol dm<sup>-3</sup> potassium cyanate solution.

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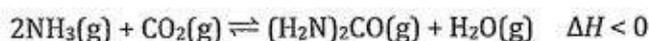
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**17e. [1 mark]**

Urea can also be made by the direct combination of ammonia and carbon dioxide gases.



Predict, with a reason, the effect on the equilibrium constant, *K<sub>c</sub>*, when the temperature is increased.

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**17f. [1 mark]**

Suggest one reason why urea is a solid and ammonia a gas at room temperature.

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