General Certificate of Education (Advanced Level) Examination

Chemistry

Alkanes

(Worksheet)

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BSc Engineering (1st Class Hons)

1. (i) What is the general formula for a noncyclic alkane?

(ii) If a noncyclic alkane contains 5 carbon atoms, how many hydrogen atoms does it contain?

(iii) A non-cyclic alkane contains five carbon atoms. Draw and name all possible isomers of this alkane.

2. (i) Write the electron configuration of carbon atom when it is at ground state.

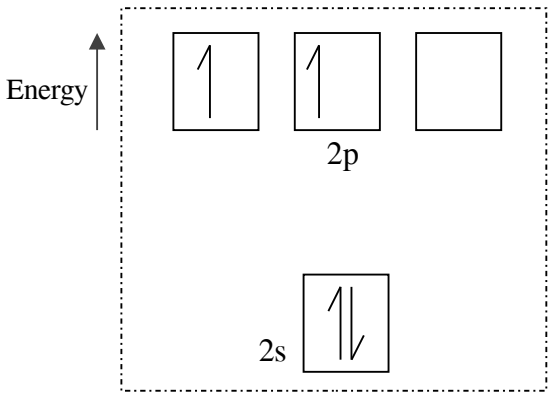
(ii) Draw the orbital diagram of the valence shell of a carbon atom.

(iii) How many unpaired electrons are there in a carbon atom when it is at ground state?

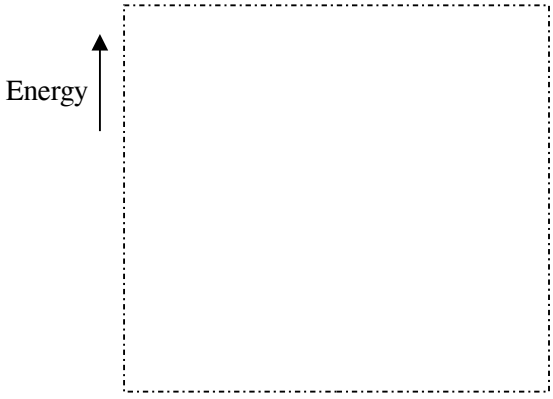
(iv) Draw the orbital diagram of the valence shell of a carbon atom when it is excited (when electrons are promoted)

(v) What should be the hybridization of the carbon atom in the CH_4 molecule?

(vi) Consider the hybridization state of the carbon atom of the CH_4 molecule. In the box A, below is a schematic representation of the electron distribution in the outer shell of a carbon atom in the ground state. Each cell in the box represents an atomic orbital. (The vertical position of the cells indicates the relative energy levels of the orbitals.)



Box : A
The ground state of the carbon atom



Box : B
The hybridization state of the carbon atom of the CH_4 molecule

Draw the hybridized orbitals of the carbon atom of the CH_4 molecule in the Box B, shown above, using cells similar to those in the Box A. Name the orbitals represented by the cells. Indicate the distribution of electrons in the cells in the Box B, as shown in the Box A.

Noteworthy:

When drawing these cells in the Box B, pay attention to the vertical position of the cells relative to the cells in the Box A.

(vii) Draw the orbital distribution with respect to the hybridization state of the carbon atom of the CH_4 molecule.

(viii) Show in a schematic diagram how atomic orbitals overlap to form the CH_4 molecule.

(ix) Complete the blanks in the following passage with suitable words / symbols.

A ..... covalent bond forms between the carbon atom and the hydrogen atom through the .... of the carbon atom's .... orbital with the ..... electrons in its valence shell and the .... orbital of the hydrogen atom, which also has ..... electrons.

Similarly, the carbon atom forms ..... additional .... bonds with ..... other hydrogen atoms.

3. Arrange the following compounds from the lowest to the highest boiling point.

(i) (a) $CH_3\,CH_3$ (b) $CH_3\,CH_2\,CH_3$ (c) $CH_3\,CH_2\,CH_2\,CH_3$

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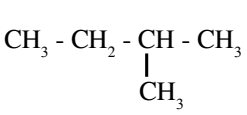
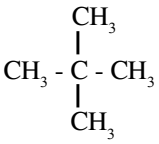
(ii) (a) $CH_3CH_2\,CH_2\,CH_2\,CH_2$ (b)  (c) 

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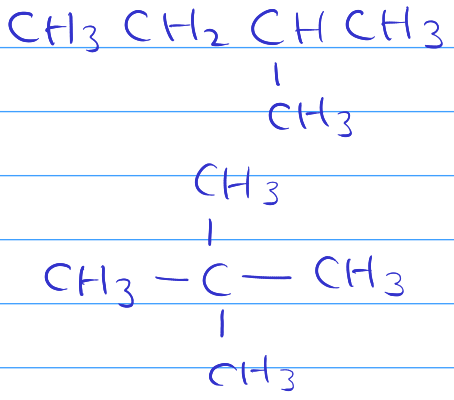
It's better to try answering on your own before checking the given answers.

1.(i) C_nH_{2n+2}

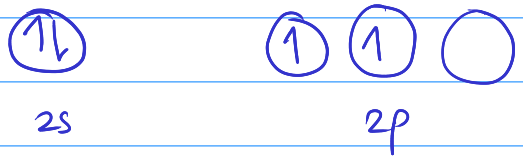
(ii) 12

(iii) C_5H_{12}

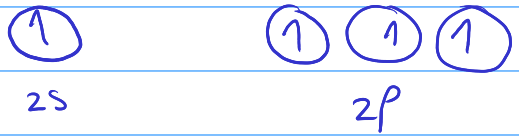
$CH_3CH_2CH_2CH_2CH_3$



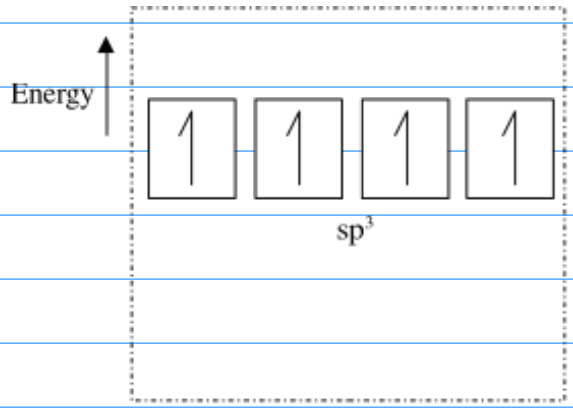
2(i) $1s^2\ 2s^2\ 2p^2$

(ii) 

(iii) 2

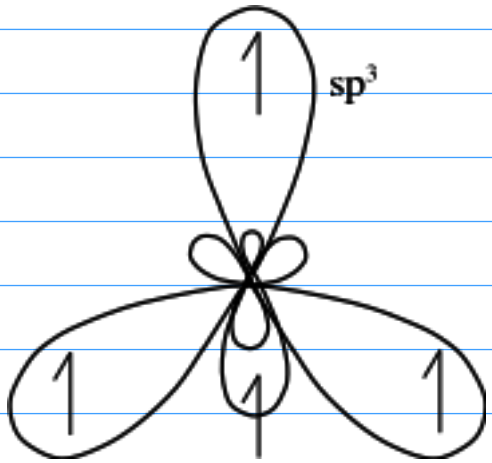
(iv) 

(v) sp^3

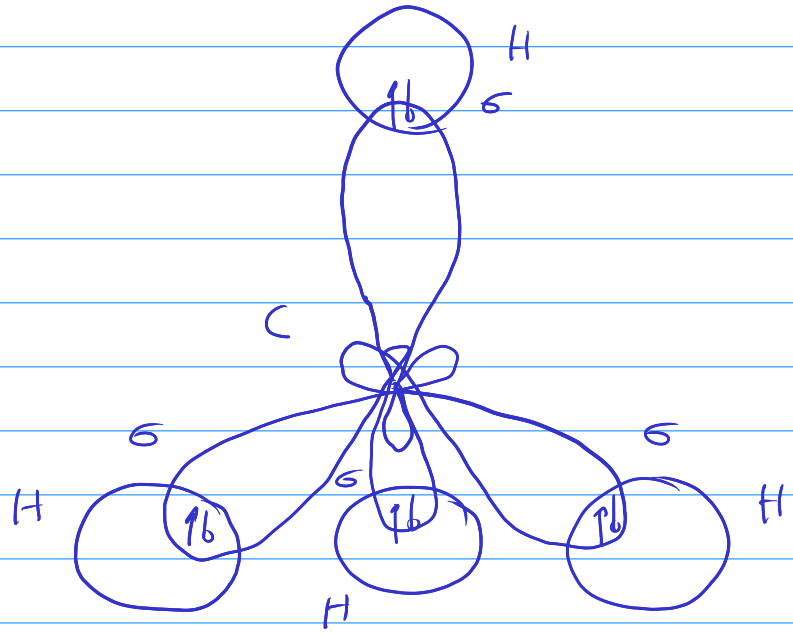
(vi) 

Box : B
The hybridization state of the carbon atom of the CH_4 molecule

(vii)



(viii)



(ix)

A ..σ (sigma).. covalent bond forms between the carbon atom and the hydrogen atom through the ..linear.. ..overlapping.. of the carbon atom's ..sp^3.. ..hybrid.. orbital with the ..unpaired.. electrons in its valence shell and the ..1s.. ..atomic.. orbital of the hydrogen atom, which also has ..unpaired.. electrons.

Similarly, the carbon atom forms ..3.. additional ..σ.. ..covalent.. bonds with ..3.. other hydrogen atoms.

3. (i) (a) $CH_3–CH_3$ < (b) $CH_3–CH_2–CH_3$ < (c)$CH_3–CH_2–CH_2–CH_3$

Explanation: All three are non-polar alkanes.

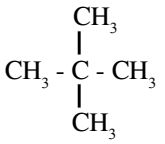
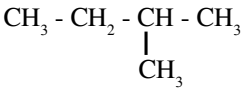
Their boiling points depend mainly on: strength of London dispersion forces.

As the carbon chain length increases, the strength of London dispersion forces increases.

This leads to an increase of boiling point.

Boiling point data

Compound	Formula	Boiling point (°C)
Ethane	C_2H_6	–89
Propane	C_3H_8	–42
n-Butane	C_4H_{10}	–0.5

(ii) (c)  < (b)  < (a) $CH_3CH_2\ CH_2\ CH_2\ CH_2$

Explanation

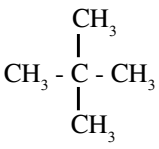
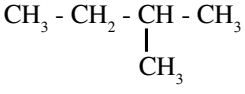
All are structural isomers with the same molecular formula (C_5H_{12}).

Here, boiling point depends mainly on degree of branching:

More branching leads to reduce the ability to move closer to each other, which leads to weaker London forces.

Therefore, more branching resulsts lower boiling point.

Boiling point data

Compound	Structure type	Boiling point (°C)
	Highly branched	9.5
	Moderately branched	27.8
$CH_3CH_2\ CH_2\ CH_2\ CH_2$	Straight chain	36.1