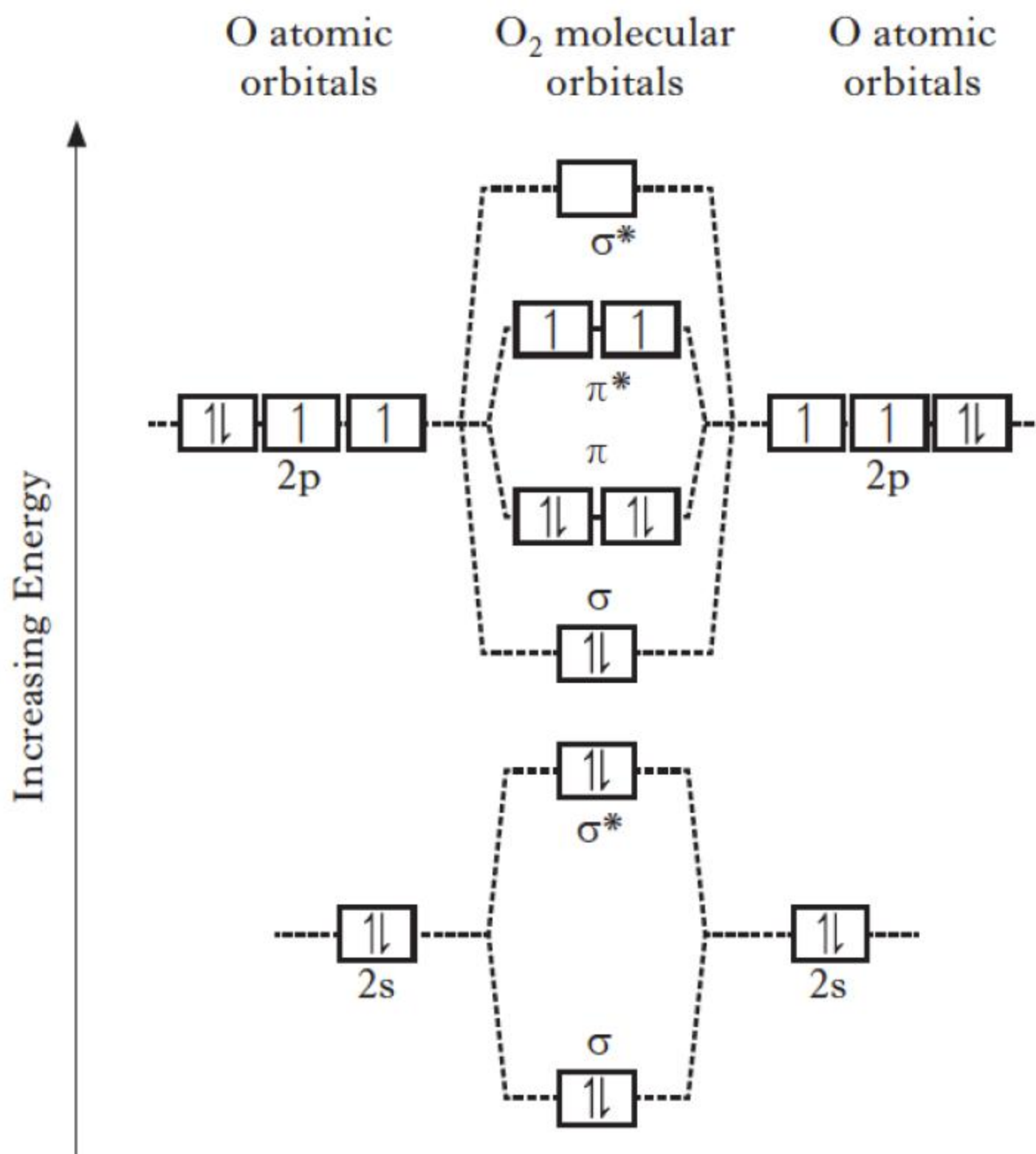


Q: 1. The stability of a covalent bond is related to its bond order, which can be defined as follows:

$$\text{bond order} = \frac{1}{2} (\text{number of bonding electrons} - \text{number of anti-bonding electrons})$$

The molecular orbital diagram for oxygen is shown. The anti-bonding orbitals are denoted by *.

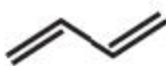
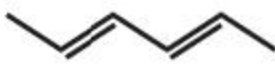

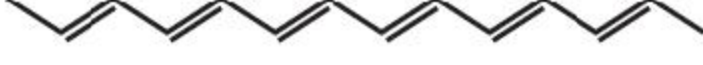


The bond order for a molecule of oxygen is

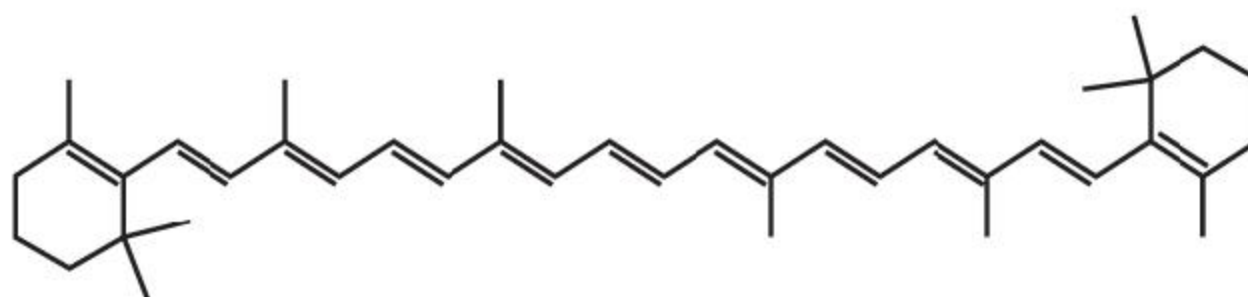
- A 0
- B 1
- C 2
- D 3.

Q. 2. The electronic spectra of molecules can be described in terms of the wavelength of maximum absorbance, λ_{\max} .

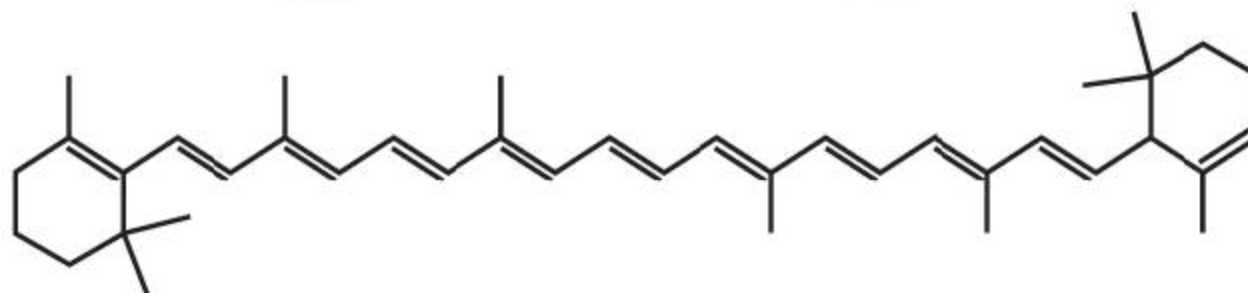
The table below shows a number of compounds with their corresponding λ_{\max} values.

Compound	λ_{\max}/nm
1. 	217
2. 	227
3. 	263
4. 	352

- a) Compound 1 is buta-1,3-diene.
Name compound 2. 1
- b) Draw the most likely structure for the compound with $\lambda_{\max} = 291 \text{ nm}$. 1
- c) The compounds shown have a system of alternating single and double bonds.
What word is used to describe this type of system? 1
- d) From the information shown in the table draw a conclusion relating the energy difference between the HOMO and the LUMO as the number of alternating single and double bonds increases. 1
- e) β -carotene, $\lambda_{\max} = 452 \text{ nm}$ gives the orange colour to carrots and has the structure

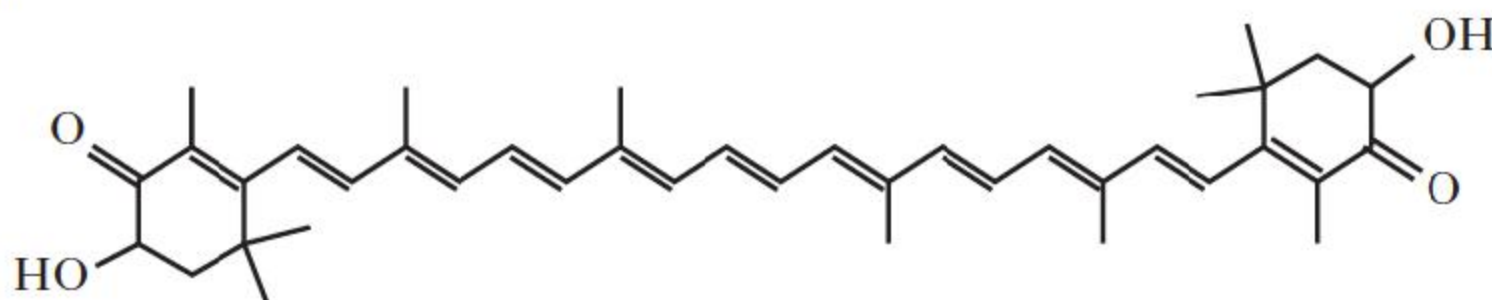


whereas α -carotene, $\lambda_{\max} = 434 \text{ nm}$ is found in oranges and has the structure:



Explain why there is a difference in the λ_{\max} values for these two structures. 1

- f) The pink colour of cooked salmon and lobster is due to astaxanthin which has the structure:



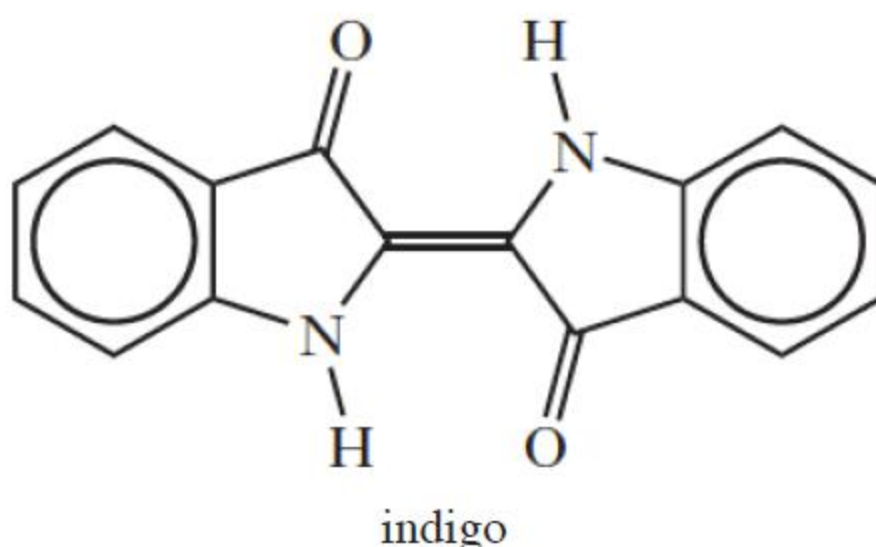
This molecule is optically active. Draw part of the molecule and circle one of the asymmetric carbon atoms responsible for this optical activity. 1

Q. 3. Lycopene and β -carotene are coloured organic compounds found in ripened tomatoes. Both absorb light in the visible region. Lycopene is red and β -carotene is orange.

Which of the following statements is true about the highest occupied molecular orbital (HOMO) and lowest unoccupied molecular orbital (LUMO) in lycopene and β -carotene?

- A** β -Carotene has a higher energy gap between HOMO and LUMO than lycopene.
- B** Lycopene has a higher energy gap between HOMO and LUMO than β -carotene.
- C** β -Carotene has the same energy gap between HOMO and LUMO as lycopene.
- D** The colour of β -carotene and lycopene is not affected by the energy gap between HOMO and LUMO.

Q. 4. The blue colour of denim jeans comes from a dye known as indigo.



The synthesis of this dye involves a series of complex chemical reactions.

- a)* What structural feature of indigo dye allows it to absorb light within the visible region of the electromagnetic spectrum? 1
 - b)* Why does a dye, such as indigo, appear blue when viewed in daylight? 1
 - c)* Draw a structural formula for the geometric isomer of indigo. 1
- (3)

5. What kind of molecular orbital (σ , σ^* , π , or π^*) is formed when the pairs of atomic orbitals shown below interact in the manner indicated?

