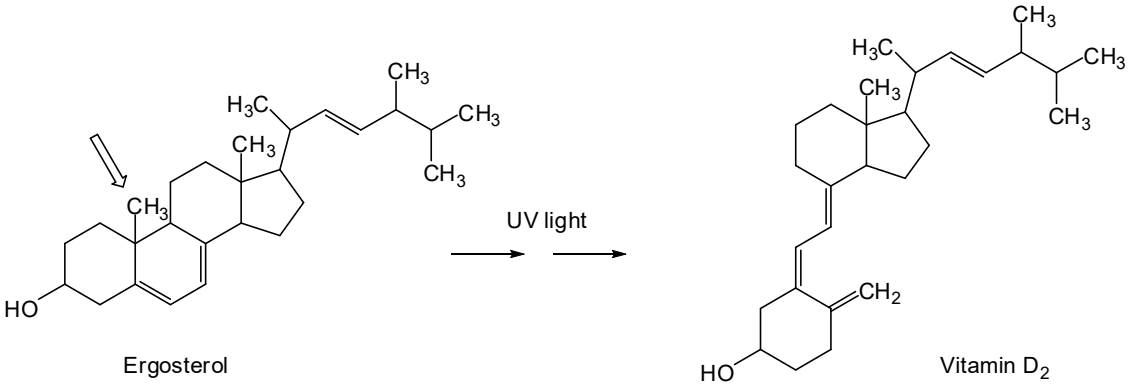
2. This question is about the kinetics of Vitamin D production in mushrooms

Vitamin D is essential for healthy bone structure. Mushrooms are a rich source of ergosterol, a precursor of vitamin D_2. Cultivated mushrooms grown in the dark have little vitamin D_2, but when exposed to UV light, ergosterol is converted into vitamin D_2.

In a kinetics experiment, different mushroom varieties were irradiated with UV light for varying periods of time and then analysed for their concentrations of ergosterol and vitamin D_2.



Ergosterol Vitamin D_2

(a) Circle all the chiral centres on the structure of ergosterol in your answer booklet.

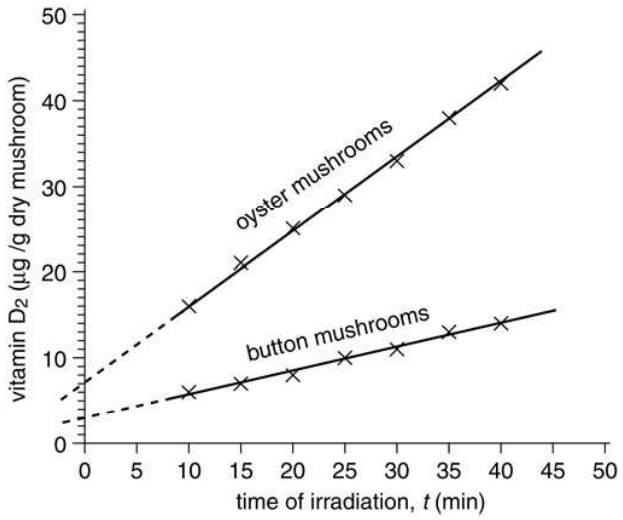
(b) During the reaction, one of the hydrogens from the methyl group marked with an arrow on the structure of ergoesterol above is transferred to a different carbon in the product. On the structure of vitamin D_2 in your answer booklet, circle the carbon atom to which the hydrogen is transferred.

The kinetics of production of vitamin D_2 from ergosterol were expected to be of the form:

$$\text{rate of production of vitamin } D_2 = k \times [\text{ergosterol}]^a$$

where k is the rate constant for the particular mushroom;
[ergosterol] is the concentration of the reactant ergosterol;
a is the order of reaction with respect to the concentration of ergosterol.

The concentrations of vitamin D_2 in oyster mushrooms and button mushrooms after irradiating the mushrooms for different periods of time are shown over the page. Both graphs are linear.



(c) By examining the graphs, what is the value of a, the observed order of reaction with respect to [ergosterol]?

minus one zero one two three

(Circle the correct answer in your answer booklet.)

(d) From the graph, determine the rate constant for the production of vitamin D_2 from oyster mushrooms. Include the correct units in your answer.

(e) Estimate the amount of vitamin D_2 in 10 g of dried button mushrooms that have been irradiated for 1 hour.

The rate constant for the production of vitamin D_2 is found to vary with temperature according to the Arrhenius equation:

$$k_{(T)} = A \times e^{(-E_a/RT)}$$

where $k_{(T)}$ is the rate constant at temperature *T*;

A is a constant;
E_a is the activation energy for the reaction;
T is the temperature in K;
R is the gas constant = 8.314 J K^{-1} mol^{-1}.

(f) Given that the rate constant for the production of vitamin D_2 from shiitake mushrooms at 35 °C is *twice* that at 25 °C, calculate the activation energy for the reaction.