

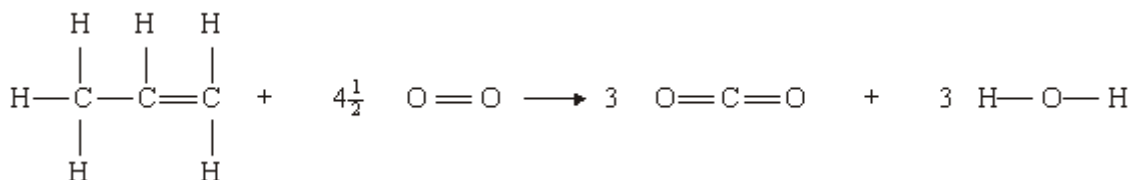
**Q1.** (a) Define the term *standard enthalpy of combustion*,  $\Delta H_c^\ominus$

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(3)

(b) Use the mean bond enthalpy data from the table and the equation given below to calculate a value for the standard enthalpy of combustion of propene. All substances are in the gaseous state.

Bond	C = C	C—C	C—H	O = O	O = C	O—H
Mean bond enthalpy/ kJ mol <sup>-1</sup>	612	348	412	496	743	463



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(3)

(c) State why the standard enthalpy of formation,  $\Delta H_f^\ominus$ , of oxygen is zero.

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(1)

(d) Use the data from the table below to calculate a more accurate value for the standard enthalpy of combustion of propene.

Compound	C <sub>3</sub> H <sub>6</sub> (g)	CO <sub>2</sub> (g)	H <sub>2</sub> O(g)
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Standard enthalpy of formation, $\Delta H_f^\ominus$ / kJ mol <sup>-1</sup>	+20	-394	-242
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(3)

- (e) Explain why your answer to part (b) is a less accurate value than your answer to part (d).

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(2)

(Total 12 marks)

- Q2.** (a) Explain the meaning of the terms *mean bond enthalpy* and *standard enthalpy of formation*.

*Mean bond enthalpy* .....

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*Standard enthalpy of formation* .....

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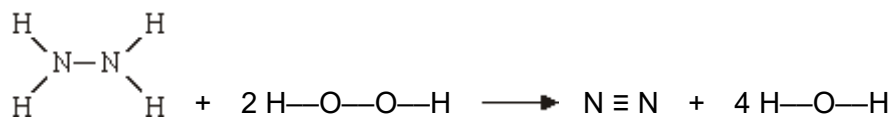
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(5)

(b) Some mean bond enthalpies are given below.

Bond	N-H	N-N	N≡N	H-O	O-O
Mean bond enthalpy/kJ mol <sup>-1</sup>	388	163	944	463	146

Use these data to calculate the enthalpy change for the following gas-phase reaction between hydrazine, N<sub>2</sub>H<sub>4</sub>, and hydrogen peroxide, H<sub>2</sub>O<sub>2</sub>



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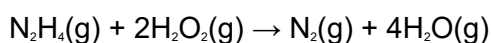
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(3)

(c) Some standard enthalpies of formation are given below.

	N <sub>2</sub> H <sub>4</sub> (g)	H <sub>2</sub> O <sub>2</sub> (g)	H <sub>2</sub> O(g)
ΔH <sub>f</sub> <sup>o</sup> /kJ mol <sup>-1</sup>	+75	-133	-242

These data can be used to calculate the enthalpy change for the reaction in part (b).



(i) State the value of ΔH<sub>f</sub><sup>o</sup> for N<sub>2</sub>(g).

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(ii) Use the ΔH<sub>f</sub><sup>o</sup> values from the table to calculate the enthalpy change for this reaction.

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(4)

- (d) Explain why the value obtained in part (b) is different from that obtained in part (c)(ii).

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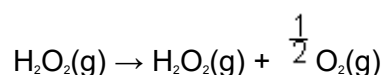
(1)

(Total 13 marks)

- Q3.** (a) The table below contains some mean bond enthalpy data.

Bond	H–O	O–O	O=O
Mean bond enthalpy/kJ mol <sup>-1</sup>	463	146	496

The bonding in hydrogen peroxide, H<sub>2</sub>O<sub>2</sub>, can be represented by H–O–O–H. Use these data to calculate the enthalpy change for the following reaction.



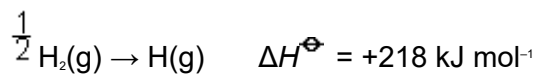
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(3)

- (b) The standard enthalpy of formation,  $\Delta H_f^\ominus$  for methane, is  $-74.9 \text{ kJ mol}^{-1}$ . Write an equation, including state symbols, for the reaction to which this enthalpy change applies.

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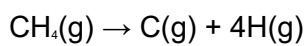
- (c) The enthalpy changes for the formation of atomic hydrogen and atomic carbon from their respective elements in their standard states are as follows.



- (i) By reference to its structure, suggest why a large amount of heat energy is required to produce free carbon atoms from solid carbon.

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- (ii) Parts (b) and (c) give enthalpy data for the formation of CH<sub>4</sub>(g), H(g) and C(g). Use these data and Hess's Law to calculate the value of the enthalpy change for the following reaction.



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- (iii) Use your answer from part (c)(ii) to calculate a value for the mean bond enthalpy of a C–H bond in methane.

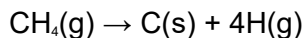
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(5)  
(Total 10 marks)

**Q4.** Given the following data



which one of the following is the enthalpy change, in  $\text{kJ mol}^{-1}$ , of the reaction below?



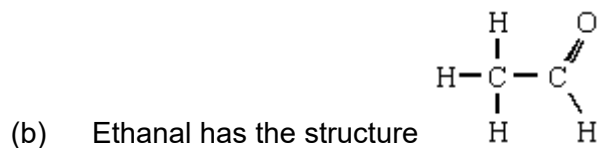
- A** -947
- B** +511
- C** +797
- D** +947

**(Total 1 mark)**

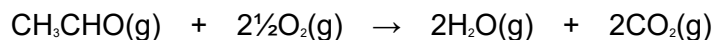
**Q5.** (a) State what is meant by the term *mean bond enthalpy*.

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**(2)**



Gaseous ethanal burns as shown by the equation



Use the mean bond enthalpy data given below to answer the following questions.

Bond	Mean bond enthalpy/ $\text{kJ mol}^{-1}$
C—H	+413
C—C	+347

C=O	+736
O=O	+498
O—H	+464

- (i) Calculate the enthalpy change which occurs when all the bonds in the reactants shown in the above equation are broken.

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- (ii) Calculate the enthalpy change which occurs when all the bonds in the products shown in the above equation are formed.

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- (iii) Hence, calculate the enthalpy change for the complete combustion of ethanal as shown in the equation above.

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(5)  
(Total 7 marks)

Q6. The table below contains some mean bond enthalpy data.

Bond	H—H	C—C	C=C	N≡N	N—H
Mean bond enthalpy / kJ mol <sup>-1</sup>	436	348	612	944	388

(a) Explain the term *mean bond enthalpy*.

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(b) (i) Write an equation for the formation of one mole of ammonia, NH<sub>3</sub>, from its elements.

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(ii) Use data from the table above to calculate a value for the enthalpy of formation of ammonia.

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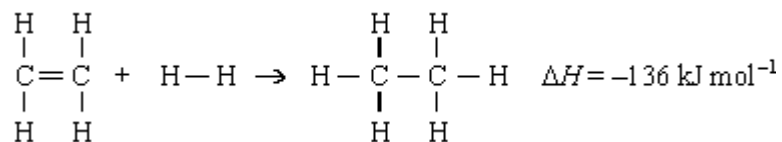
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(4)

(c) Use the following equation and data from the table above to calculate a value for the C—H bond enthalpy in ethane.



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**(3)**  
**(Total 9 marks)**