INTERNATIONAL BACCALAUREATE
BACCALAURÉAT INTERNATIONAL
BACHILLERATO INTERNACIONAL

N01/420/H(3)

CHEMISTRY
HIGHER LEVEL
PAPER 3

Wednesday 14 November 2001 (morning)

1 hour 15 minutes

Name

Number

INSTRUCTIONS TO CANDIDATES

- Write your candidate name and number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all of the questions from two of the Options in the spaces provided. You may continue your answers in a continuation answer booklet, and indicate the number of booklets used in the box below. Write your name and candidate number on the front cover of the continuation answer booklets, and attach them to this question paper using the tag provided.
- At the end of the examination, indicate the letters of the Options answered in the boxes below.

OPTIONS ANSWERED		EXAMINER	TEAM LEADER	IBCA
		/25	/25	/25
		/25	/25	/25
NUMBER OF CONTINUATION BOOKLETS USED	. . . . .	TOTAL /50	TOTAL /50	TOTAL /50

Option C – Human biochemistry

C1. Fats and oils are made from a molecule of propane-1,2,3-triol joined to three molecules of alkanoic (fatty) acids.

(a) Give the structural formula of propane-1,2,3-triol. *[1]*

(b) Give the formula of the functional group common to all alkanoic acids and draw the structural formula of an alkanoic acid which contains eight carbon atoms per molecule. *[2]*

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(c) Explain the difference between saturated and unsaturated fats in terms of their molecular structures and explain briefly how the degree of unsaturation can be determined experimentally. *[4]*

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C2. The two ends of the primary structure of a myoglobin molecule are shown below:

X-Val-Leu-Ser-Glu-Gly————————————————Gly-Tyr-Gln-Gly-COOH

Val, Leu, Ser *etc.* refer to the different amino acids in the chain.

(a) Identify the functional group represented by **X**. *[1]*

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(b) Name the covalent bond formed between **each** pair of amino acids in the chain. Draw a diagram of this bond to show clearly the atoms present in it and how they are joined to each other. *[2]*

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(c) Describe briefly a technique that might have been used to identify the primary structure of myoglobin. *[2]*

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(d) Explain what is meant by the *secondary* and *tertiary structure* of myoglobin. *[2]*

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(e) Name the type of bond responsible for the secondary structure of myoglobin. *[1]*

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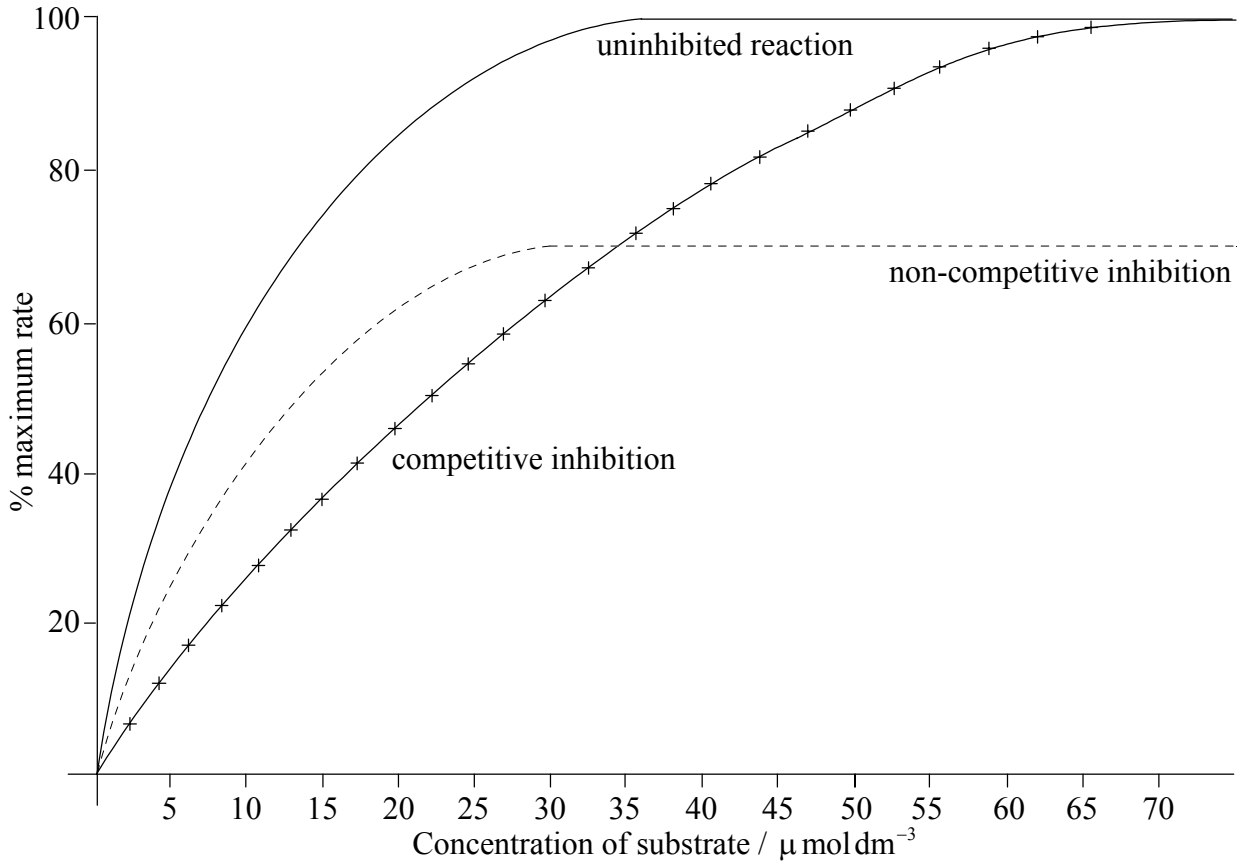
C3.



The graph above shows how the rate of an enzyme catalysed reaction varies with substrate concentration for the uninhibited enzyme, for competitive inhibition and for non-competitive inhibition.

(a) Explain in both energy and structural terms how enzymes are able to catalyse specific biological reactions. Describe the difference in the way that competitive and non-competitive inhibitors interact with the enzyme. *[5]*

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(Question C3 continued)

(b) Use the graph to calculate K_m for the uninhibited reaction. State and explain how the values of both K_m and V_{max} are affected by both competitive and non-competitive inhibitors. *[5]*

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Option D – Environmental chemistry

D1. (a) CO, NO, SO_2 and hydrocarbons are primary air pollutants.

(i) The levels of CO and NO produced by automobiles can be lowered by a catalytic converter. Write a balanced chemical equation for the reaction that takes place between these two primary pollutants in a catalytic converter. *[2]*

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(ii) SO_2 is produced from the burning of coal. It can be removed from the exhaust gases of coal-burning power plants by alkaline scrubbing. Write a balanced chemical equation for the reaction that takes place in the scrubber. *[2]*

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(b) Write chemical equations to show the formation of acid rain from **one** of the primary pollutants above. *[2]*

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(c) State **one** adverse health effect of hydrocarbons. *[1]*

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D2. Three different types of pollutants which can be found in water are heavy metals, pesticides and PCBs.

(a) What do the letters PCB stand for? *[1]*

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(b) The toxicity of pesticides can be expressed either as an LD_{50} *value* or as a *maximum daily tolerance value*.

(i) State what is meant by both LD_{50} *value* and *maximum daily tolerance value*. *[2]*

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(ii) State **one** advantage and **one** disadvantage associated with **either** of the two values. *[2]*

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(c) Mercury is a heavy metal which is toxic to humans.

(i) State **one** common source of mercury in polluted water. *[1]*

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(ii) State **one** symptom shown by humans who are suffering from mercury poisoning. *[1]*

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(iii) Explain why mercury is poisonous to humans. *[1]*

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D3. Explain why water is such a good solvent for many substances. State **two** reasons why the supply of fresh water is inadequate to meet global demands. Explain the principles behind the use of both reverse osmosis and ion exchange to obtain fresh water from sea water. *[10]*

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Option E – Chemical industries

E1. In the Haber process, nitrogen and hydrogen are passed through a compressor and a converter containing a catalyst. The equation for the reaction is:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(a) State how the nitrogen and hydrogen are obtained for this process.

(i) Nitrogen: *[1]*

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(ii) Hydrogen: *[1]*

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(b) State and explain **two** chemical reasons why the compressor is used. *[4]*

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(c) Explain why much of the material which comes through the converter is recycled. *[2]*

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E2. Low density polythene is produced by a free radical mechanism. One step in this mechanism is:

$$HO{-}CH_2{-}CH_2^{\bullet} + H_2C{=}CH_2 \rightarrow HO{-}CH_2{-}CH_2{-}CH_2{-}CH_2^{\bullet}$$

(a) Describe the movement of electrons and the changes in bonding that occur in this step. *[3]*

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(b) Write the equation for the next step in the mechanism. *[1]*

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(c) State the essential difference between the mechanisms for the formation of low density polythene and for the formation of high density polythene. *[1]*

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(d) State the conditions required for the manufacture of high density polythene. *[2]*

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(e) Polythene is an addition polymer whereas polyurethane is a condensation polymer which contains the $-O-\overset{\overset{O}{\|}}{C}-\overset{\overset{H}{|}}{N}-$ linkage. Give the formulas of **two** functional groups which could combine to form the polyurethane linkage. *[2]*

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E3. A number of conversion processes are used in oil refineries in order to obtain useful products from oil fractions. Consider **two** such conversion processes, one in which the temperature is varied and one in which a catalyst is used. In **each** case, state the reactants and products, and explain how the conditions are adjusted to maximise yield. *[8]*

Option F – Fuels and energy

F1. There are several different types of batteries.

(a) Name the substances used to make the anode (negative electrode), the cathode (positive electrode) and the electrolyte in the Leclanché dry cell. *[3]*

Anode: . . . . . .

Cathode: . . . . . .

Electrolyte: . . . . . .

(b) Write equations to show what happens at each electrode when the cell is in use. *[2]*

Anode: . . . . . .

Cathode: . . . . . .

(c) Alkaline batteries are more expensive than Leclanché cells. State **two** advantages of alkaline batteries. *[2]*

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(d) State and explain the effect of increasing the surface area of the electrodes on the voltage of a battery. *[2]*

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F2. (a) ^{144}Cs, ^{90}Rb, neutrons and energy can be produced when an atom of ^{235}U is struck by a neutron.

(i) Write the nuclear equation for this reaction. *[2]*

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(ii) During the reaction 0.10 % of ^{235}U is converted into energy. Calculate the energy which will be produced from 1.0 kg of ^{235}U during this conversion. *[2]*

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(b) 16.0 g of ^{32}P was found to have decayed so that only 1.00 g of ^{32}P remained after 57.2 days. Calculate the half-life of ^{32}P. *[2]*

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F3. (a) Describe the fractional distillation of crude oil. Your answer should include details of the boiling range, number of carbon atoms per molecule and use for any **three** different fractions obtained. *[7]*

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(b) Some fractions are subsequently cracked. Give a balanced equation to show the cracking of $C_{12}H_{26}$ and state the major use of **each** product. *[3]*

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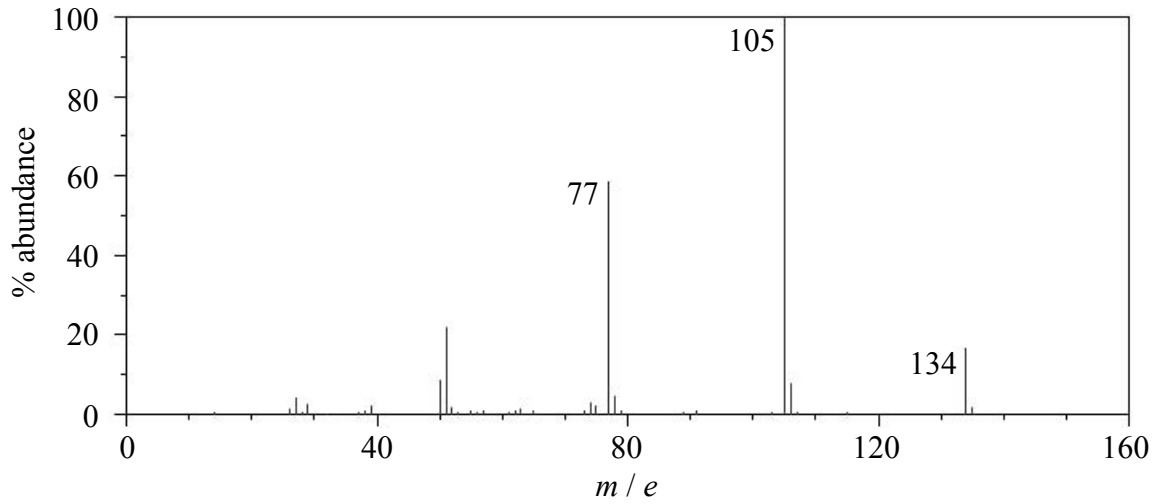
Option G – Modern analytical chemistry

G1. An organic compound **A** was found by analysis to have the empirical formula $C_9H_{10}O$.

(a) The mass spectrum of compound **A** is given below:



(i) What does the peak at 134 represent and what information about compound **A** can be deduced from it? *[2]*

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(ii) There is a small peak at 135. Explain what causes this peak. *[1]*

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(iii) Suggest which fragments are responsible for the peaks at 105 and 77. *[2]*

105: . . . . . 77: . . . . . .

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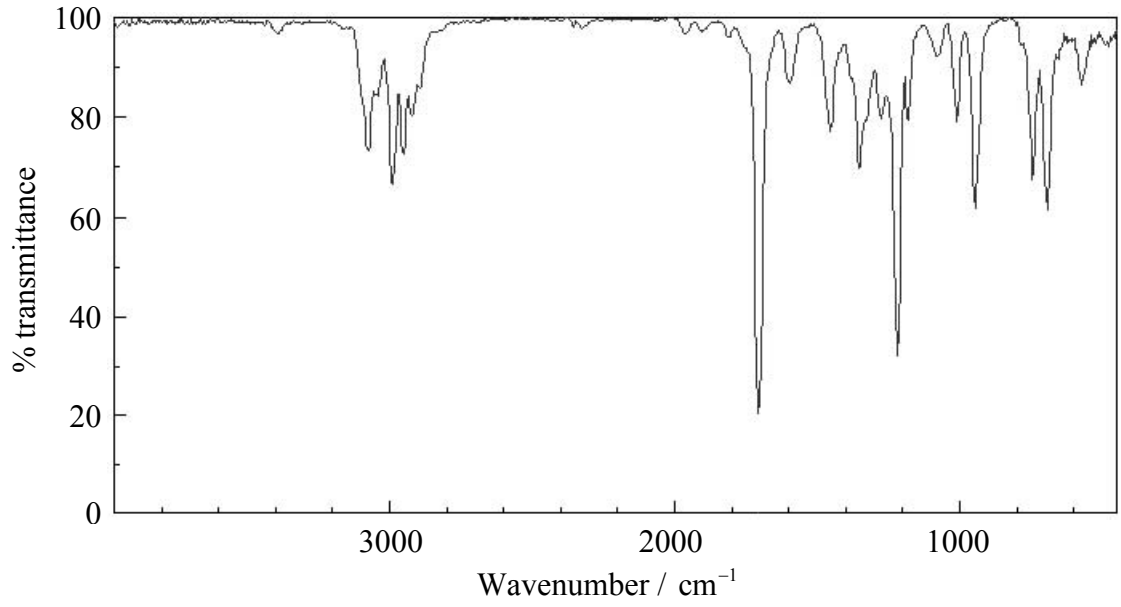
(Question G1 continued)

(b) The infra-red spectrum of compound **A** is shown below:



(i) What information does the absorption at 1690 cm^{-1} give about compound **A**? *[1]*

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(ii) There is a sharp absorption at 2950 cm^{-1}. What could this be due to? *[1]*

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(iii) The infra-red spectrum of compound **A** does **not** show a broad absorption at about 3300 cm^{-1}. What information does this give about compound **A**? *[1]*

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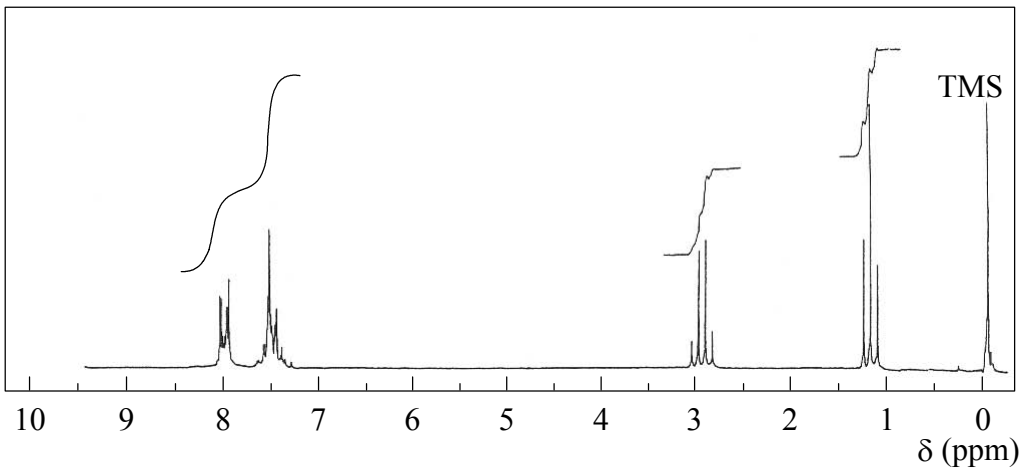
(Question G1 continued)

(c) The ^{1}H NMR spectrum of compound **A** is shown below:



(i) Give the molecular formula for the compound responsible for the peak at 0 ppm and suggest **two** reasons why it is used as a reference. *[3]*

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(ii) What information do the integration lines give about the numbers of protons with chemical shifts at 1.2, 3.0 and 7.3–8.1 ppm? *[1]*

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(iii) The shifts at 1.2 and 3.0 ppm are split into a triplet and a quartet respectively. What information does this splitting pattern give about the structure of compound **A**? *[2]*

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(iv) What information about compound **A** can be deduced from the peaks occurring between 7.3 and 8.1 ppm? *[1]*

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(This question continues on the following page)

(Question G1 continued)

(d) Give the structural formula for compound **A**. *[2]*

G2. (a) Explain why transition metal complexes are coloured. *[3]*

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(b) A student wishes to use a visible spectrometer to determine the exact concentration of a solution of copper(II) sulfate which is approximately 0.01 $mol\,dm^{-3}$. She has access to a standard solution of 1.00 $mol\,dm^{-3}$ copper(II) sulfate solution. Outline the procedure she needs to follow to obtain as accurate a result as possible. *[5]*

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Option H – Further organic chemistry

H1. Bromine can react with benzene by an electrophilic substitution mechanism.

(a) Give the chemical equation for the formation of bromobenzene from benzene and bromine. *[1]*

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(b) State the necessary conditions for this reaction to take place. *[2]*

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(c) Identify the species which acts as the electrophile and show how it is formed. *[2]*

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(d) Give the mechanism for the reaction between bromine and benzene, clearly showing the structural formula of the organic intermediate formed. *[2]*

(e) Describe and explain how the reactivity of phenol with bromine compares with that of benzene with bromine. Your answer should include any difference in the reaction conditions and include the structural formula of the main product formed. *[4]*

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H2. (a) Explain why but-2-ene can exist as two geometric isomers whereas but-1-ene cannot. *[2]*

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(b) (i) When HBr is added to both of the geometric isomers of but-2-ene-1,4-dioic acid, $HOOCCHBrCH_2COOH$ is produced. Give the structural formulas of the two stereoisomers of this product, showing clearly how the structures differ. *[2]*

(ii) State the difference in the physical properties of these two stereoisomers and identify the feature of these molecules which is responsible for this property. *[2]*

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H3. When hydrogen bromide reacts with 2-methylpropene, two products are possible.

(a) Give the structural formula of the major product formed. *[1]*

(b) Name the mechanism for this reaction. Outline the steps involved and describe and explain the relative stabilities of the two possible organic intermediate species. *[7]*

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