



**CHEMISTRY  
HIGHER LEVEL  
PAPER 3**

Thursday 5 May 2005 (morning)

1 hour 15 minutes

Candidate session number

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**INSTRUCTIONS TO CANDIDATES**

- Write your session 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 on answer sheets. Write your session number on each answer sheet, and attach them to this examination paper and your cover sheet using the tag provided.
- At the end of the examination, indicate the letters of the Options answered in the candidate box on your cover sheet and indicate the number of answer sheets used in the appropriate box on your cover sheet.

**Option B – Medicines and drugs**

**B1.** Analgesics can be classified as mild or strong.

(a) State and explain how each type of analgesic prevents pain. [4]

*mild analgesic*

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*strong analgesic*

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(b) Aspirin is a common mild analgesic.

(i) Outline **one** advantage and **one** disadvantage of using aspirin. [2]

*advantage*

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*disadvantage*

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(ii) State **one** synergistic effect of using aspirin and ethanol together. [1]

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(iii) Acetaminophen (paracetamol) is often used as a substitute for aspirin. State **one** disadvantage of using acetaminophen. [1]

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**B2.** (a) Compare broad-spectrum and narrow-spectrum antibiotics. [1]

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(b) State how penicillins prevent the growth of bacteria and explain why scientists continue to develop new penicillins. [2]

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(c) Explain the specific effects of modifying the side chain in penicillin. [1]

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(d) (i) Discuss the possible effects of over prescribing penicillin to humans. [3]

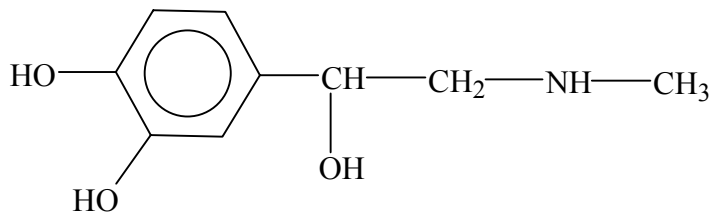
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(ii) Suggest another practice that may lead to these results. [1]

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**B3.** Many drugs and other biologically important molecules consist of chiral species whose activity depends upon the enantiomer used. Adrenaline (a hormone that is also used as a drug) is a chiral molecule.

- (a) Identify by means of an asterisk (\*) the chiral centre in adrenaline, the structure of which is given below. [1]



- (b) Some enantiomers can be prepared by using a chiral auxiliary. Outline how a chiral auxiliary functions and state the advantage it provides. [4]

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**B4.** (a) Lysergic acid diethylamide (also known as LSD or “acid”) and mescaline are both mind-altering drugs. State **one** effect caused by both substances and **one** effect caused by LSD or mescaline only. (*Specify the substance which causes the effect.*) [2]

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(b) Outline the structural similarities and differences between LSD and mescaline. (Structures are given in Table 21 of the *Data Booklet*.) [2]

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**Option C – Human biochemistry**

**C1.** (a) A brand of vegetable fat consists of 88 % unsaturated fats and 12 % saturated fats. State the major structural difference between unsaturated and saturated fats. [1]

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(b) Linoleic acid,  $\text{CH}_3(\text{CH}_2)_4\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$ , and palmitic acid,  $\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$ , are components of vegetable fat. Explain why palmitic acid has the higher melting point. [3]

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(c) The energy content of a vegetable oil was determined using a calorimeter. A 5.00 g sample of the oil was completely combusted in a calorimeter containing 1 000 g of water at an initial temperature of 18.0 °C . On complete combustion of the oil, the temperature of the water rose to 65.3 °C .

Calculate the calorific value of the oil in  $\text{kJ g}^{-1}$ .

[4]

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**C2.** By referring to Table 22 of the *Data Booklet*, identify **one** vitamin that is water soluble and **one** vitamin that is fat soluble. Explain the differences in solubility in terms of their structures and intermolecular forces.

[4]

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**C3.** Discuss **two** benefits and **two** concerns of using genetically modified foods.

[4]

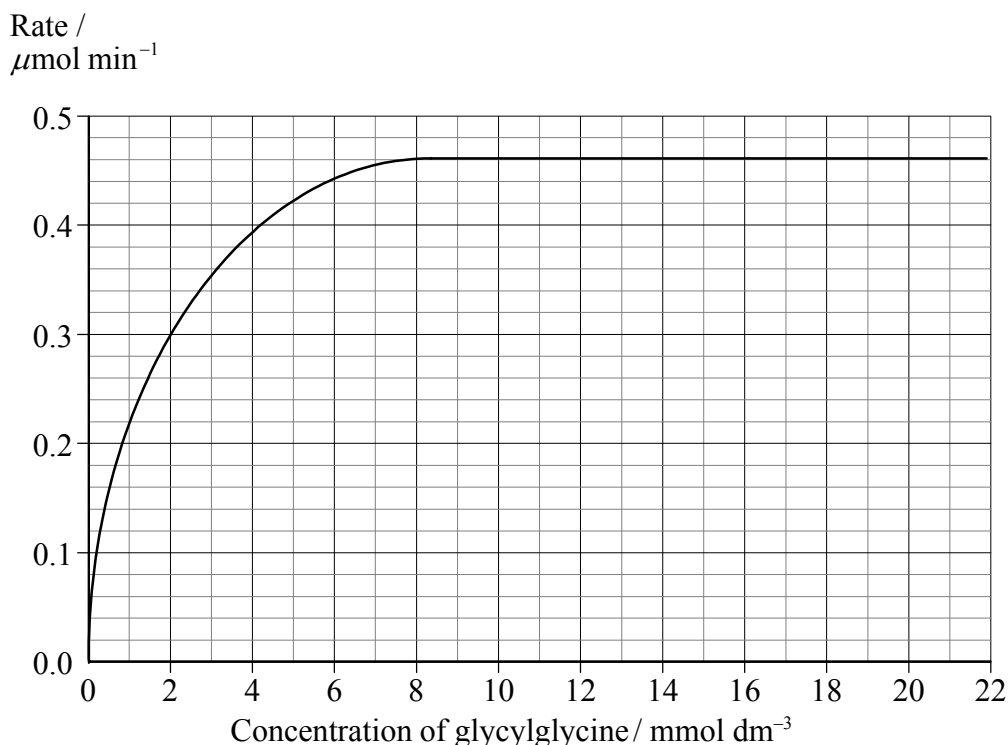
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C4. (a) State the function of enzymes in the human body. [1]

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(b) The enzyme peptidase is capable of hydrolysing the dipeptide glycylglycine. Use the graph below to determine  $V_{\max}$  and the Michaelis constant,  $K_m$ . [2]

Rate versus concentration



$V_{\max}$  .....  $K_m$  .....

(c) Explain how the rate of this hydrolysis reaction is affected by an increase in substrate concentration. Outline the significance of  $V_{\max}$ . [3]

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(d) On the above graph draw a line to represent the effect of adding a competitive inhibitor. [1]



**C5.** Iron ions are important in the process of carrying oxygen around the body. Name the substance with which iron is complexed and give the oxidation state of the iron ion. [2]

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**Option D – Environmental chemistry**

**D1.** (a) List **two** gases which contribute to the greenhouse effect. [1]

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(b) Explain how greenhouse gases cause global warming. [3]

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**D2.** (a) Identify **one** pollutant that contributes to the lowering of the ozone concentration in the upper atmosphere. State a source of the pollutant identified. [2]

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(b) Fluorocarbons and hydrofluorocarbons are now considered as alternatives to some ozone-depleting pollutants. Outline **one** advantage and **one** disadvantage of the use of these alternatives. [2]

*advantage*

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*disadvantage*

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- D3.** (a) The initial stages of waste water treatment are known as primary and secondary stages. For each stage, outline the nature of the treatment and the substance removed. [4]

*primary stage*

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*substance removed*

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*secondary stage*

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*substance removed*

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- (b) State **two** types of substances removed during the tertiary treatment of waste water and explain how they are removed during this stage. [4]

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**D4.** Identify **one** primary and **one** secondary pollutant in photochemical smog and describe the formation of secondary pollutants. State why the condition of thermal inversion is ideal for the formation of photochemical smog. [4]

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**D5.** Heavy metals such as mercury, lead and cadmium may pollute waterways. State **two** sources of **one** of these heavy metals and outline **one** environmental effect and **one** human health effect. [3]

sources

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environmental effect

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human health effect

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**D6.** Discuss the disadvantages of using LD<sub>50</sub> as a means of expressing toxicity in water. [2]

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**Option E – Chemical industries**

**E1.** (a) Describe the structural difference between isotactic and atactic polypropene. You may use a diagram to show the difference. [2]

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(b) List **two** properties of isotactic polypropene and outline how its structure leads to these properties. [2]

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**E2.** (a) State the essential chemical process in the extraction of iron and aluminium. [1]

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(b) Using iron and aluminium as examples, discuss the major factor that determines the ease of extraction of all metals. [2]

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**E3.** Iron is produced in a blast furnace.

(a) State the name and write the formula of the main ore from which iron is extracted. [1]

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(b) (i) State the name and write the formula of the main impurity in iron ore. [1]

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(ii) Name the raw material used to remove the impurity. Show with equations how the impurity is removed. [2]

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(c) State the process used to extract aluminium on an industrial scale and write the equations for the reactions involved. [3]

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(d) Explain the use of cryolite in the production of aluminium, other than cost. [2]

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**E4.** The electrolysis of brine is the basis of the chlor-alkali industry. Discuss the production of chlorine by this method by referring to

- (i) equations showing the electrode reactions [2]
- (ii) **two** methods of ensuring that the electrode reactions occur separately [1]
- (iii) the names of the other two products and **one** industrial use of each. [2]

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**E5.** Explain what is added when silicon is doped to produce n-type and p-type semiconductors. [4]

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**Option F – Fuels and energy**

**F1.** (a) The energy stored in biomass can be released in several ways. Two of these are direct combustion and conversion to ethanol. For **each** of these two methods, give **one** advantage and **one** disadvantage.

(i) direct combustion [2]

*advantage*

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*disadvantage*

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(ii) conversion to ethanol [2]

*advantage*

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*disadvantage*

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(b) Solar energy can be converted to electricity by means of photovoltaic cells. Give **one** advantage and **one** disadvantage of using photovoltaic cells. [2]

*advantage*

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*disadvantage*

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**F2.** Electrical energy can be produced from chemical energy by the use of batteries.

- (a) (i) Explain the workings of the lead-acid storage battery. Your answer should include
- the materials used for each electrode
  - the identity of the electrolyte
  - the half-equation for the reaction that occurs at each electrode.

[5]

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- (ii) Identify the type of reaction that occurs at the negative electrode (anode) and explain your answer.

[2]

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(b) With reference to a lead storage battery, identify the factors that affect the

- (i) voltage produced.

[1]

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- (ii) power obtained.

[1]

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**F3.** Phosphorus-31 is stable but phosphorus-33 is radioactive.

(a) Predict the mode of radioactive decay for P-33 and explain your answer. [2]

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(b) P-33 has a half-life of 25 days.

(i) Determine the rate constant,  $k$ . [1]

(ii) Calculate the fraction of a P-33 sample that decays in 7 days. [2]

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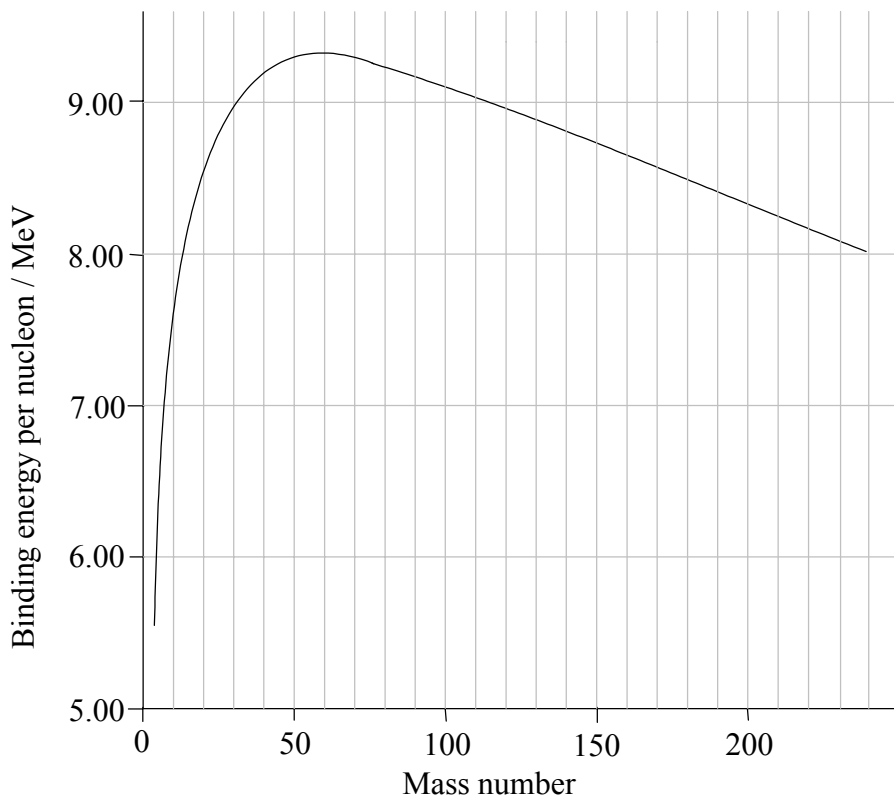
F4. The graph below shows the relationship between the binding energy per nucleon and mass number.

(a) Define the term *nuclear binding energy*. [1]

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(b) Use the following graph to account for the fact that nuclear fission and nuclear fusion both release energy. Explain why the curve ends near mass number 240. [4]

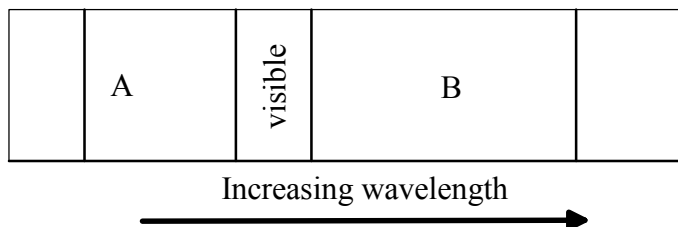
Binding Energy per Nucleon versus Mass number



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**Option G – Modern analytical chemistry**

**G1.** The figure below depicts the visible region of the electromagnetic spectrum and the two regions nearest to it.



(a) Name the regions labelled A and B, identify the atomic or molecular processes associated with each region and compare the energies of the photons involved in these processes. [5]

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(b) State, giving a reason, which region (A or B) could be used to

(i) test for metal ions. [1]

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(ii) obtain information about the strengths of bonds. [1]

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**G2.** (a) Draw structures for **two** possible isomers of a compound with the formula  $C_2H_4O_2$ . [2]

(b) The infrared spectrum of this compound shows the following absorptions: 2920, 2765 and  $1710\text{ cm}^{-1}$ . Use the information in Table 18 of the *Data Booklet* to assign each absorption to a particular vibration. [2]

$2920\text{ cm}^{-1}$  .....  
.....  
 $2765\text{ cm}^{-1}$  .....  
.....  
 $1710\text{ cm}^{-1}$  .....  
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(c) Deduce the structure from (a) which would demonstrate the infrared absorptions above. Explain your answer. [2]

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**G3.** (a)  $^1\text{H}$  NMR spectroscopy can be used to obtain information about the structure of molecules. State the information that can be obtained from the

(i) number of peaks. [1]

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(ii) chemical shift. [1]

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(iii) ratio of peak areas. [1]

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(iv) splitting pattern. [1]

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(b) The  $^1\text{H}$  NMR spectrum of a compound with the formula  $\text{C}_4\text{H}_8\text{O}_2$  exhibits three major peaks with chemical shifts, areas and splitting patterns given below. [3]

chemical shift / ppm	peak area	splitting pattern
0.9	3	triplet
2.0	2	quartet
4.1	3	singlet

Using information from Table 19 in the *Data Booklet*, determine the types of proton present in the molecule.

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*(This question continues on the following page)*

*(Question G3 continued)*

- (c) Deduce a structure consistent with the information indicated in (b). Explain your answer. [5]

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**Option H – Further organic chemistry**

**H1.** Methylbenzene,  $C_6H_5CH_3$ , reacts with  $Cl_2$  to form different products depending on the conditions used. For the gas-phase reaction of  $C_6H_5CH_3$  and  $Cl_2$  in ultraviolet light,

(a) draw a structural formula for the product  $C_7H_7Cl$ . *[1]*

(b) provide a stepwise mechanism, clearly labelling each step. *[5]*

(c) explain the role of the ultraviolet light. *[1]*

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**H2.** When hydrogen cyanide reacts with an aldehyde or a ketone the product molecule has one more carbon atom.

(a) Give a mechanism for the reaction of hydrogen cyanide with propanone. [4]

(b) Write an equation for the acid hydrolysis of this product. State the **two** functional groups in the organic product. [2]

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**H3.** The rates and mechanisms of nucleophilic substitution reactions depend on several factors.

- (a) Both  $\text{CH}_3\text{Br}$  and  $(\text{CH}_3)_3\text{CBr}$  react with aqueous sodium hydroxide. Identify the type of nucleophilic substitution in each reaction. Explain each mechanism in terms of the inductive and steric effects. [6]

$\text{CH}_3\text{Br}$

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$(\text{CH}_3)_3\text{CBr}$

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- (b) State and explain the relative rates of reaction of  $\text{CH}_3\text{Br}$  with  $\text{OH}^-$  and  $\text{H}_2\text{O}$ . [3]

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*(This question continues on the following page)*

*(Question H3 continued)*

- (c) State and explain the relative rates of the nucleophilic substitution reactions of  $\text{CH}_3\text{Br}$  and  $\text{C}_6\text{H}_5\text{Br}$ .

[3]

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