



CHEMISTRY
STANDARD LEVEL
PAPER 3

Thursday 13 May 2010 (morning)

1 hour

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 A — Modern analytical chemistry

A1. Butan-1-ol, butan-2-ol, 2-methylpropan-1-ol and 2-methylpropan-2-ol are four structural isomers with the molecular formula $C_4H_{10}O$.

(a) Details of the 1H NMR spectra of two of these alcohols are given below.

Spectrum 1

Two peaks: One at 1.3 ppm (relative to the TMS reference) with an integration trace of nine units, and the other at 2.0 ppm with an integration trace of one unit.

Spectrum 2

Four peaks: The first at 0.9 ppm with an integration trace of six units.
The second at 1.7 ppm with an integration trace of one unit.
The third at 2.1 ppm with an integration trace of one unit.
The fourth at 3.4 ppm with an integration trace of two units.

Consider the proton environments present in each of the alcohol molecules when answering the following questions.

(i) Identify which alcohol gives spectrum 1 and explain your answer by stating which hydrogen atoms in the molecule are responsible for each of the two peaks. [3]

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(ii) Deduce which alcohol gives spectrum 2. Explain which particular hydrogen atoms in the molecule are responsible for the peaks at 0.9 ppm and 3.4 ppm. [3]

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(Question A1 continued)

(b) The mass spectrum of one of the alcohols shows peaks at m/z values of 74, 59 and 45.

(i) Deduce which **two** of the alcohols could produce this spectrum and identify the species responsible for the three peaks. [4]

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(ii) The spectrum also shows a significant peak at $m/z = 31$. Suggest which alcohol is responsible for this spectrum and deduce the species responsible for the peak at $m/z = 31$. [2]

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(c) Explain why the infrared spectra of all four alcohols are very similar. [2]

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A2. Atomic absorption spectroscopy can be used to determine the concentration of lead ions in a contaminated sample of drinking water.

(a) State **one** other use of atomic absorption spectroscopy. [1]

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(b) Describe the function of each of the following in an atomic absorption spectrophotometer. [3]

The fuel:

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The atomizer:

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The monochromatic light source:

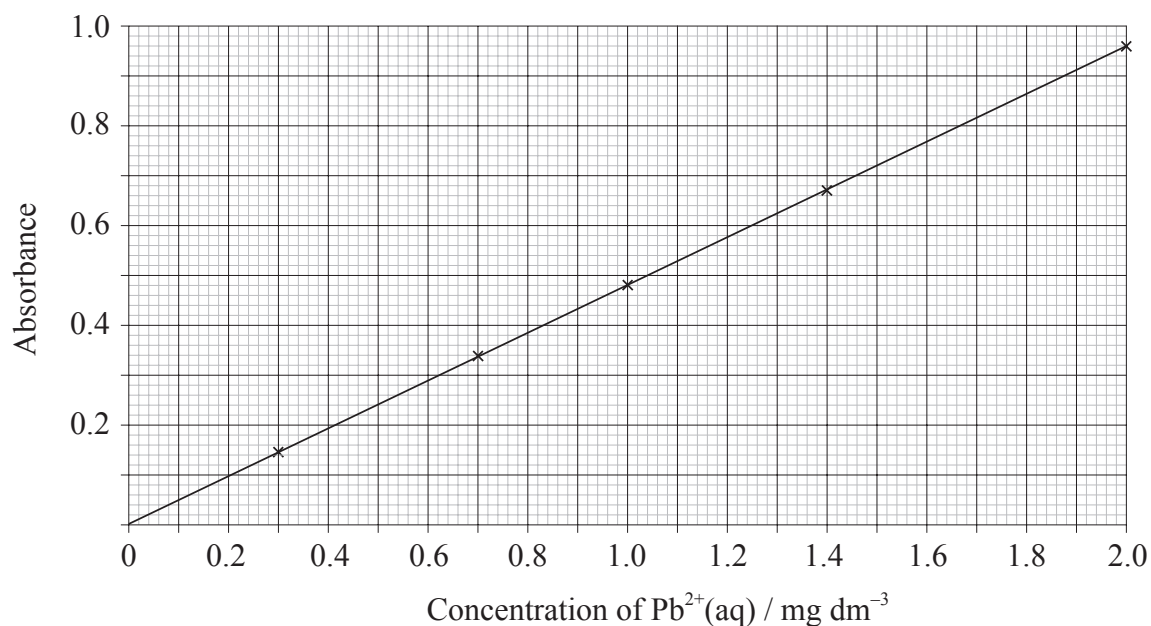
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(Question A2 continued)

(c) A calibration curve was plotted using water with known concentrations of lead ions.



100 dm³ of the contaminated drinking water was reduced by boiling, to 7.50 dm³. It was found that when the reduced volume was tested it had an absorbance of 0.55. Calculate the concentration of lead ions (in mg dm⁻³) in the original contaminated drinking water. [2]

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Option B — Human biochemistry

B1. Individual 2-amino acids have different structures depending on the pH of the solution they are dissolved in. The structures of serine and cysteine are given in Table 19 of the Data Booklet.

(a) Deduce the structure of serine in

(i) a solution with a pH of 2. [1]

(ii) a solution with a pH of 12. [1]

(b) Deduce the structure of serine at the isoelectric point. [1]

(c) Deduce the structures of the two different dipeptides that can be formed when one molecule of serine reacts with one molecule of cysteine. [2]

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(Question B1 continued)

- (d) The tertiary structures of proteins made up of 2-amino acid residues such as serine and cysteine, are the result of interactions between amino acids to give a three-dimensional shape. State **five** different types of interaction that can occur, in each case identify the atoms or groups joined together. [5]

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B2. (a) State the causes of the three deficiency diseases, beriberi, goitre and pellagra. [3]

Beriberi:

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Goitre:

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Pellagra:

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(b) Suggest **three** ways in which society can solve the problems associated with malnutrition. [3]

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B3. Unsaturated fats contain C=C double bonds. The amount of unsaturation in a fat or oil can be determined by titrating with iodine solution.

(a) Define the term *iodine number*. [1]

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(b) Linoleic acid ($M_r = 281$) has the following formula.



Calculate the volume of 1.00 mol dm^{-3} iodine solution required to react exactly with 1.00 g of linoleic acid. [3]

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Option C — Chemistry in industry and technology

C1. (a) Explain why iron is obtained from its ores using chemical reducing agents but aluminium is obtained from its ores using electrolysis. [2]

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(b) Both carbon monoxide and hydrogen can be used to reduce iron ores. State the equations for the reduction of magnetite, Fe₃O₄, with

(i) carbon monoxide. [1]

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(ii) hydrogen. [1]

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(c) Explain why much of the iron produced in a blast furnace is converted into steel. [2]

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(d) State the materials used for the positive and negative electrodes in the production of aluminium by electrolysis. [2]

Positive electrode:

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Negative electrode:

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(Question C1 continued)

- (e) Aluminium is one of the most abundant elements found on Earth. Discuss why it is important to recycle aluminium. [2]

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C2. (a) Use high-density poly(ethene) and low-density poly(ethene) as examples to explain the difference that branching can make to the properties of a polymer. [3]

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(b) During the formation of poly(styrene), a volatile hydrocarbon such as pentane is often added. Describe how this affects the properties of the polymer and give **one** use for this product. [2]

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C3. (a) State the difference between homogeneous and heterogeneous catalysts. [1]

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(b) State **one** advantage and **one** disadvantage that homogeneous catalysts have over heterogeneous catalysts. [2]

Advantage:

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Disadvantage:

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(c) Apart from their selectivity to form the required product and their cost, discuss **two** other factors which should be considered when choosing a suitable catalyst for an industrial process. [2]

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Option D — Medicines and drugs

D1. Aspirin, paracetamol (acetaminophen), morphine and diamorphine (heroin) are all pain killers. Their structures are given in Table 20 of the Data Booklet.

(a) Aspirin is thought to interfere with the production of prostaglandins. Explain how this produces an analgesic effect. [1]

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(b) Explain how morphine can prevent pain. [1]

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(c) Paracetamol (acetaminophen) is generally considered to be safe to use as an analgesic in small doses. Other than the possibility of death, outline the problems associated with taking larger doses of paracetamol. [2]

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(d) State **one** important use for aspirin other than the relief of pain and fever. [1]

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(e) Other than the phenyl group, state the name of **one** other functional group that is common to

(i) both paracetamol and morphine. [1]

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(ii) both aspirin and diamorphine. [1]

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(Question D1 continued)

- (f) Explain what is meant by the term *tolerance* and suggest why this is a particular problem for heroin users. [2]

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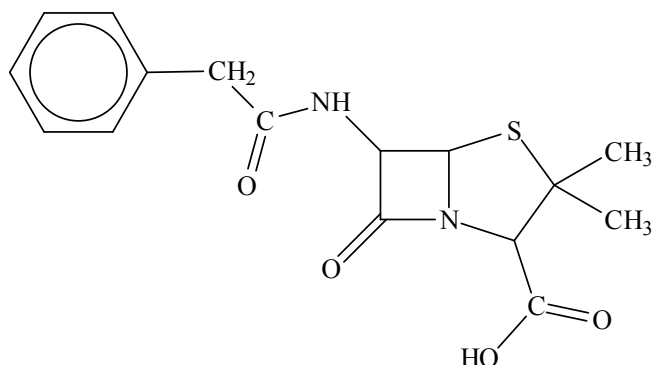
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D2. The first penicillin to be used was benzylpenicillin (Penicillin G), its structure is shown below.



(a) Explain how penicillins are able to act as antibacterials. [2]

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(b) Modern penicillins have a similar structure to Penicillin G but a different side-chain. State **two** advantages of modifying the side-chain. [2]

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(c) Discuss the reason why a “cocktail” of different antibacterials may be needed to treat tuberculosis (TB). [1]

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D3. (a) Sodium hydrogencarbonate, NaHCO_3 , and magnesium hydroxide, Mg(OH)_2 , can both be used as antacids.

(i) Give the equations for the reactions of sodium hydrogencarbonate and magnesium hydroxide with hydrochloric acid. [2]

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(ii) Compare the effectiveness of 1.00 g of sodium hydrogencarbonate to 0.50 g of magnesium hydroxide in combating acidity in the stomach. [3]

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(b) Explain why alginates are often added to antacids. [1]

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Option E — Environmental chemistry

- E1.** (a) Two primary air pollutants are carbon monoxide and oxides of nitrogen. State **one** man-made source for each of these pollutants. [2]

Carbon monoxide:

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Oxides of nitrogen:

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- (b) Explain how a catalytic converter works and give the equation for the catalysed reaction between carbon monoxide, CO, and nitrogen monoxide, NO. [3]

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- (c) State **one** other type of primary pollutant, other than carbon monoxide and oxides of nitrogen, that can also be removed from the air by a catalytic converter. [1]

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- (d) Particulates may be produced by the burning of fossil fuels. Explain how small particulates can be removed from the exhaust gases of coal-burning power stations before they enter the atmosphere. [2]

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E2. (a) The disposal of all types of waste is an increasing problem. One method of removing waste is incineration. State **one** advantage and **one** disadvantage of incinerating waste. [2]

Advantage:

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Disadvantage:

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(b) State the characteristics and sources of low-level nuclear waste. [2]

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(c) The disposal of nuclear waste in the sea is now banned in many countries. Discuss **one** method of storing high-level nuclear waste and **two** problems associated with it. [3]

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E3. (a) Stratospheric ozone is in dynamic equilibrium with oxygen. Give the equations that describe the formation of ozone from oxygen and its depletion in the stratosphere in the presence of ultraviolet light. [2]

Formation:

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Depletion:

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(b) Since the Montreal Protocol in 1987, the use of ozone-depleting CFCs has almost been phased out. Discuss **one** advantage and **two** disadvantages of using hydrocarbons such as 2-methylpropane as a replacement for CFCs. [3]

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Option F — Food chemistry

F1. Simple sugars are nutrients and are also described as monosaccharides.

(a) Distinguish between a *food* and a *nutrient*. [2]

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(b) State **three** characteristic features of all monosaccharide molecules. [3]

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(c) Explain the chemistry behind the non-enzymatic browning reaction that occurs when making fudge from sugar and cream. [3]

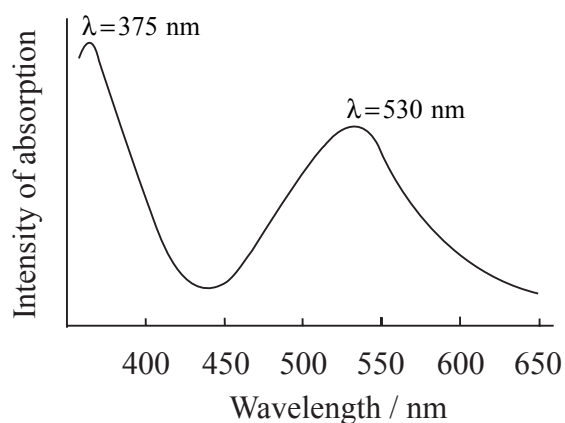
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F2. (a) Explain why pigments such as anthocyanins are coloured. [2]

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(b) The wavelength of visible light lies between 400 and 750 nm. The absorption spectrum of a particular anthocyanin is shown below.



(i) Explain what effect, if any, the absorption at 375 nm will have on the colour of the anthocyanin. [1]

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(ii) Explain what effect, if any, the absorption at 530 nm will have on the colour of the anthocyanin. [1]

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(c) List **two** factors which could alter the precise colour of a particular anthocyanin. [2]

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F3. (a) Give the general structural formula for a fat or oil and describe the difference in structure between a saturated and an unsaturated fatty acid. [2]

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(b) Explain why unsaturated fats have a lower melting point than saturated fats. [2]

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(c) Oils can be hydrogenated. One possible problem is that partial hydrogenation may occur which produces an oil containing *trans* fatty acids. Explain the structural difference between a *cis* fatty acid and a *trans* fatty acid and state **one** disadvantage of ingesting oils containing *trans* fatty acids. [2]

Difference:

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Disadvantage:

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Option G — Further organic chemistry

G1. When bromoethane reacts with magnesium in the presence of a non-polar solvent, a Grignard reagent is formed.

(a) Give the equation for the reaction of this Grignard reagent with water. [2]

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(b) This Grignard reagent can also react with aldehydes and ketones to give an initial product which can then be hydrolysed by water to form an alcohol. State the names and formulas of the alcohols formed when the Grignard reagent reacts with

(i) ethanal. [2]

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(ii) propanone. [2]

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(Question G1 continued)

(c) Alcohols can undergo elimination reactions in the presence of hot concentrated phosphoric acid.

(i) Name the organic product formed when butan-1-ol undergoes an elimination reaction. [1]

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(ii) Explain the mechanism for this elimination reaction using curly arrows to represent the movement of electron pairs. [3]



G2. Alkenes can undergo electrophilic addition reactions with bromine and with hydrogen bromide.

(a) Explain how a bromine molecule is able to act as an electrophile. [1]

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(b) Name the product formed when but-2-ene reacts with

(i) bromine. [1]

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(ii) hydrogen bromide. [1]

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(c) When but-1-ene reacts with hydrogen bromide, two possible organic products could be formed but in practice only one organic product is obtained in high yield. Explain the mechanism for this reaction using curly arrows to represent the movement of electron pairs and explain clearly why only one organic product is formed. [4]

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G3. Benzene is sometimes represented as containing three alternate double and single bonds (Fig.1) and sometimes represented as a hexagon with a circle in the middle (Fig.2).

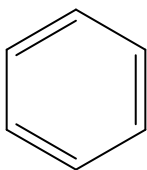


Fig.1

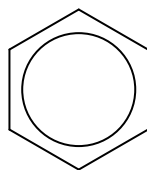


Fig.2

(a) Describe two different types of physical evidence which show that benzene does not contain three double bonds. [2]

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(b) Explain how the reaction of benzene with bromine provides chemical evidence that benzene does not contain three double bonds. [1]

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