

Chemistry

Standard level

Paper 3

Thursday 8 November 2018 (morning)

Candidate session number

1 hour

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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.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **chemistry data booklet** is required for this paper.
- The maximum mark for this examination paper is **[35 marks]**.

Section A	Questions
Answer all questions.	1

Section B	Questions
Answer all of the questions from one of the options.	
Option A — Materials	2 – 4
Option B — Biochemistry	5 – 8
Option C — Energy	9 – 11
Option D — Medicinal chemistry	12 – 16

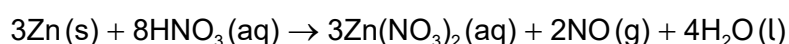
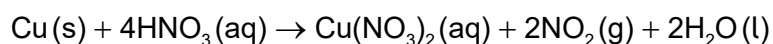


Section A

Answer **all** questions. Answers must be written within the answer boxes provided.

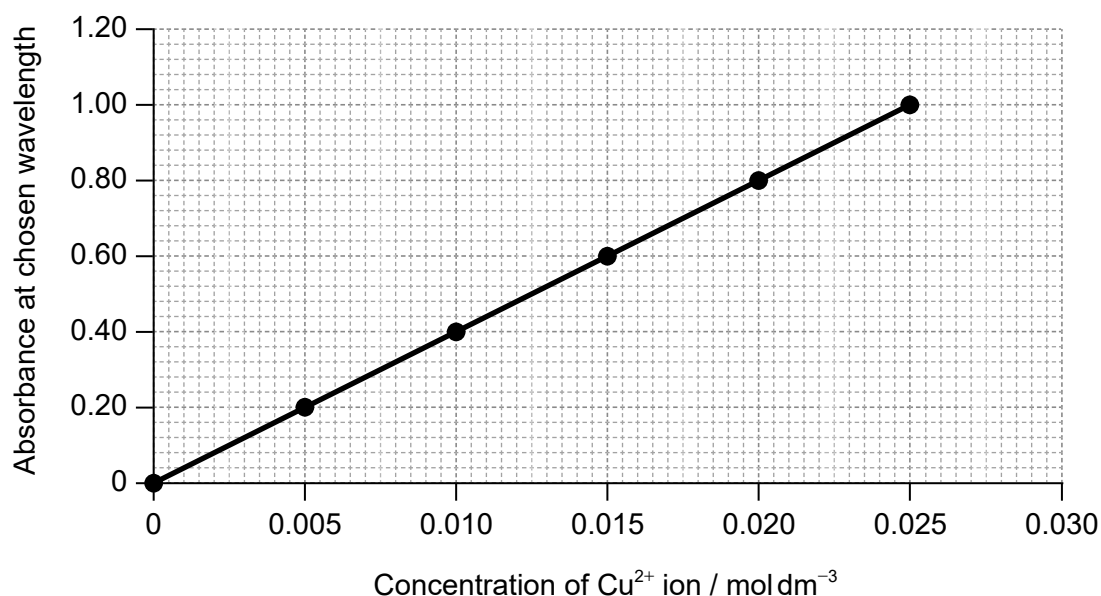
1. Alloys containing at least 60% copper reduce the presence of bacteria on their surface. The percentage of copper in brass, an alloy of copper and zinc, can be determined by UV-vis spectrometry.

A sample of brass is dissolved in concentrated nitric acid and then made up to 250.0 cm^3 with water before analysis.



The concentration of copper(II) ions in the resulting solution is then determined from a calibration curve, which is plotted by measuring the light absorbance of standard solutions.

Calibration curve



(This question continues on the following page)



(Question 1 continued)

- (a) Outline why the initial reaction should be carried out under a fume hood. [1]

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- (b) Deduce the equation for the relationship between absorbance and concentration. [2]

Slope (gradient):
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Equation:
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- (c) Outline how a solution of $0.0100 \text{ mol dm}^{-3}$ is obtained from a standard $1.000 \text{ mol dm}^{-3}$ copper(II) sulfate solution, including **two** essential pieces of glassware you would need. [3]

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(This question continues on the following page)



(Question 1 continued)

- (d) (i) The original piece of brass weighed 0.200 g. The absorbance was 0.32.

Calculate, showing your working, the percentage of copper by mass in the brass. [3]

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- (ii) Deduce the appropriate number of significant figures for your answer in (d)(i). [1]

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- (e) (i) Comment on the suitability of using brass of this composition for door handles in hospitals. [1]

If you did not obtain an answer to (d)(i), use 70% but this is not the correct answer.

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- (ii) Suggest another property of brass that makes it suitable for door handles. [1]

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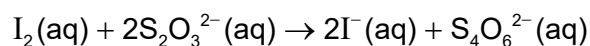
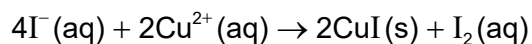
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(This question continues on the following page)



(Question 1 continued)

- (f) Titration is another method for analysing the solution obtained from adding brass to nitric acid.
- (i) Copper(II) ions are reduced to copper(I) iodide by the addition of potassium iodide solution, releasing iodine that can be titrated with sodium thiosulfate solution, Na₂S₂O₃(aq). Copper(I) iodide is a white solid.



Deduce the overall equation for the two reactions by combining the two equations. [2]

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- (ii) Suggest why the end point of the titration is difficult to determine, even with the addition of starch to turn the remaining free iodine black. [1]

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Please **do not** write on this page.

Answers written on this page
will not be marked.



Section B

Answer **all** of the questions from **one** of the options. Answers must be written within the answer boxes provided.

Option A — Materials

2. One way of classifying materials is based on the type of bonding present.

(a) Outline why this type of classification is not entirely satisfactory by using magnesium diboride, MgB_2 , as an example. Refer to sections 8 and 29 of the data booklet. [2]

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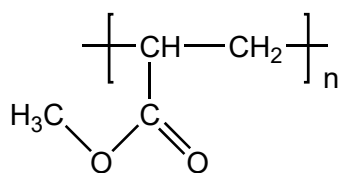
(Option A continues on the following page)



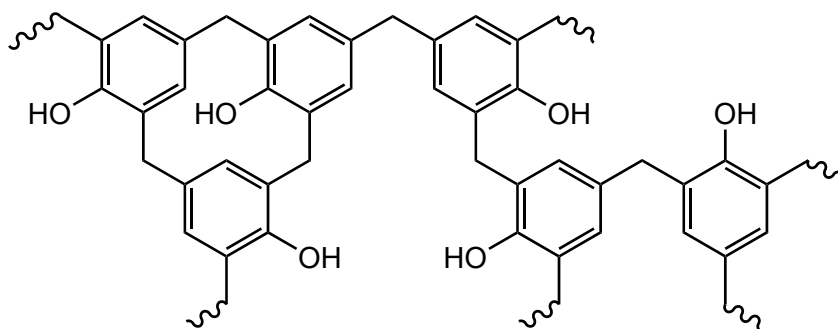
(Option A, question 2 continued)

(b) (i) Structures of poly(methyl acrylate), PMA, and Bakelite® are shown.

PMA



Bakelite®



Suggest, giving reasons, which is the thermoplastic polymer and which is the thermosetting polymer.

[2]

Thermoplastic polymer:

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Thermosetting polymer:

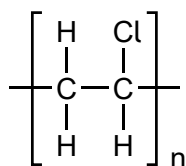
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(Option A continues on the following page)



(Option A, question 2 continued)

- (ii) In an incomplete combustion of the polyvinyl chloride, PVC, it was found that hydrogen chloride, carbon monoxide, carbon dioxide, and water vapour were released.



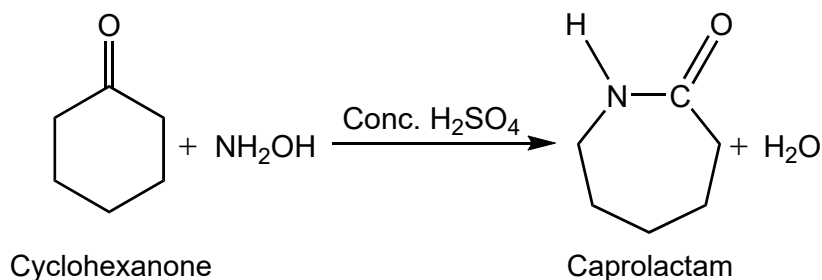
Formulate an equation for this reaction using the formula of the PVC repeating unit.

[1]

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- (c) One reaction to convert cyclohexanone to caprolactam using concentrated sulfuric acid as a catalyst is shown.



- (i) A zeolite is an alternative catalyst for this reaction. Explain how zeolites act as selective catalysts.

[2]

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- (ii) Identify another advantage of using a zeolite instead of concentrated sulfuric acid.

[1]

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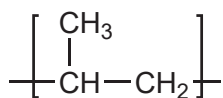
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(Option A continues on the following page)

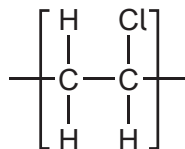


(Option A, question 2 continued)

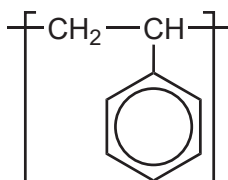
(d) Repeating units of several polymers are listed.



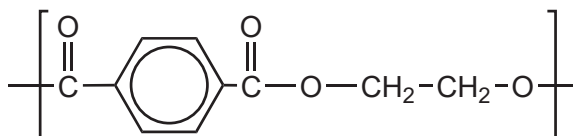
Polypropene (PP)



Polyvinyl chloride (PVC)

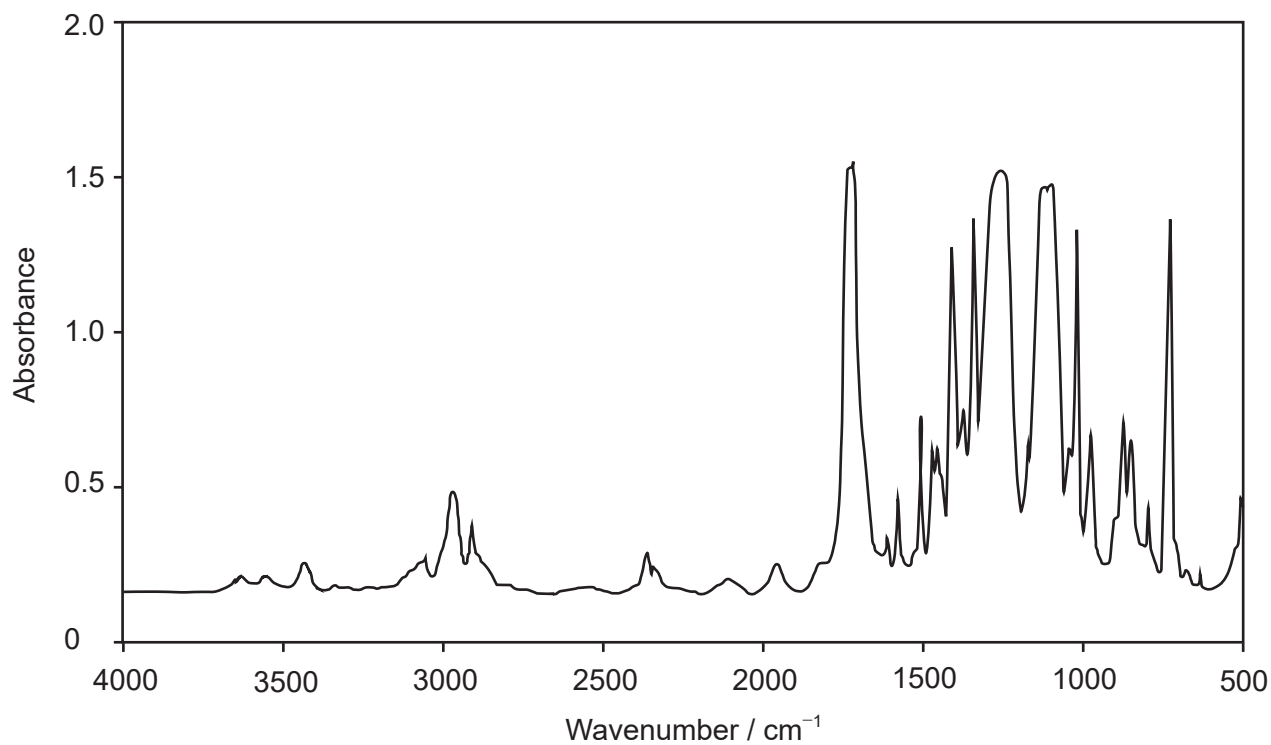


Polystyrene (PS)



Polyethylene terephthalate (PETE)

The infrared (IR) spectrum of one of these polymers is shown.



[Source: <http://iopscience.iop.org/article/10.1088/1757-899X/5/1/012005> Cristina Bach, Xavier Dauchy and Serge Etienne © 2009 IOP Publishing Ltd IOP Conference Series: Materials Science and Engineering, Volume 5, Number 1]

(Option A continues on the following page)



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(Option A, question 2 continued)

Deduce, giving a reason, the name of this polymer and its Resin Identification Code (RIC), using sections 26 and 30 in the data booklet. [2]

Name and reason:

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RIC:

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3. The presence of very small amounts of lead in calcium-based antacids can be determined using inductively coupled plasma-mass spectroscopy (ICP-MS).

(a) State the type of particle present in the plasma formed. [1]

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(b) An unknown antacid sample has a lead ion concentration of $0.50 \mu\text{g dm}^{-3}$.

Calculate the concentration of lead ions in the sample in mol dm^{-3} . [2]

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(Option A continues on the following page)



Turn over

(Option A, question 3 continued)

- (c) Electrolysis is used to obtain lead from Pb^{2+} (aq) solution.

Determine the time, in hours, required to produce 0.0500 mol lead using a current (I) of 1.34 A. Use section 2 of the data booklet and the equation, charge (Q) = current (I) \times time (t , in seconds).

[2]

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4. While heating solid cholesteryl benzoate, Reinitzer discovered the liquid crystal phase.

- (a) Outline **two** observations that he could have made.

[2]

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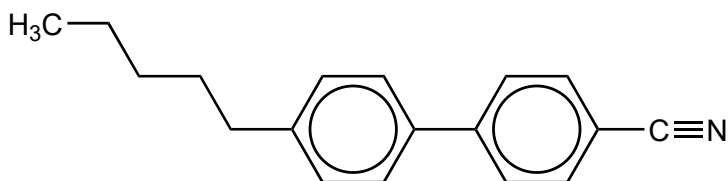
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- (b) The structure of biphenyl nitrile is shown.



Describe, giving a reason, a feature of the molecular structure, other than its polarity, that allows biphenyl nitrile to show liquid crystal behaviour.

[1]

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(Option A continues on the following page)



(Option A, question 4 continued)

- (c) Arc discharge, consisting of two inert metal electrodes in a liquid solvent, is one method of producing carbon nanotubes (CNTs).

Predict, giving a reason, the electrode at which the solvent cyclohexane, C_6H_{12} , will decompose to form CNTs.

[2]

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End of Option A



Option B — Biochemistry

5. Dietary recommendations are made by scientists.

- (a) The formation of proteins from amino acids is an example of an anabolic reaction in the human body.

State the source of energy for such a synthetic reaction. [1]

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- (b) Suggest why it is advisable for those living in northerly or southerly latitudes (that is away from the equator) to take vitamin D supplements during the winter. [1]

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- (c) Explain how a xenobiotic is biomagnified. [2]

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6. Enzymes are mainly globular proteins.

- (a) Describe the interaction responsible for the secondary structure of a protein. [2]

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(Option B continues on the following page)



(Option B, question 6 continued)

(b) (i) Explain the action of an enzyme and state one of its limitations. [3]

Enzyme action:

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Limitation:

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(ii) Enzymes are widely used in washing detergents. Outline how they improve the efficiency of the process. [1]

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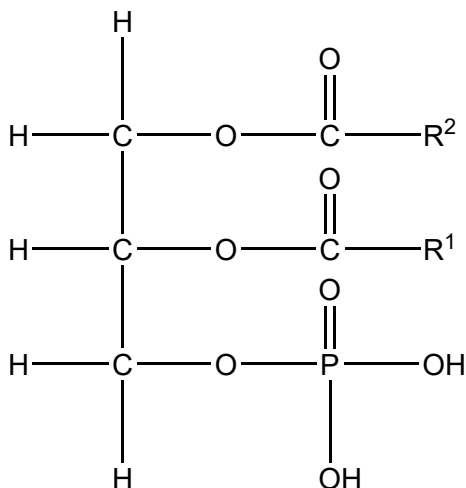
(Option B continues on the following page)



(Option B continued)

7. Lipids play several roles in our bodies.

(a) A phospholipid generally consists of two hydrophobic fatty acids and a hydrophilic group.



Fatty acids are products of the acidic hydrolysis of phospholipids. Deduce the names of the other two products. [2]

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(b) (i) The iodine number is the maximum mass of iodine that reacts with 100 g of an unsaturated compound.

Determine the iodine number of stearidonic acid, $\text{C}_{17}\text{H}_{27}\text{COOH}$. [3]

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(Option B continues on the following page)



(Option B, question 7 continued)

(ii) State **two** functions of lipids in the body. [2]

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(c) Outline one effect of increased levels of low-density lipoproteins in the blood. [1]

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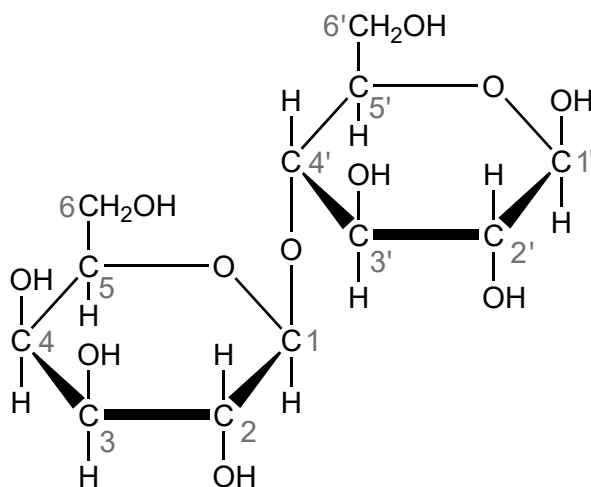
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(Option B continues on the following page)



(Option B continued)

8. Lactose, found in milk and dairy products, is a disaccharide formed from two different monosaccharides. The structure of lactose is shown with numbered carbon atoms.



- (a) Name the type of link between the two monosaccharide residues. [1]

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- (b) Outline how the two monomer structures, galactose and glucose, differ. [1]

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End of Option B



Option C — Energy

9. The Sun's energy is produced by the fusion of hydrogen nuclei.

(a) Explain fusion reactions with reference to binding energy. [2]

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(b) Uranium-238 produces plutonium-239, which is used as fuel in breeder reactors.

(i) Outline why the term breeder is used for the reactors. [1]

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(ii) Deduce the fission reaction when ^{239}Pu is bombarded with a neutron to produce ^{133}Xe and ^{103}Zr . [1]

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(c) Nuclear disasters release radioactive caesium into the atmosphere, which presents serious health risks.

Cs-137 has a half-life of 30 years.

Calculate the percentage of Cs-137 remaining in the atmosphere after 240 years. [2]

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(Option C continues on the following page)



(Option C continued)

10. Coal can be converted to clean-burning synthetic natural gas.

(a) Formulate equation(s) for the conversion of coal and steam to methane.

[1]

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(b) Automobile companies use hydrogen as an alternative to fossil fuels. Some properties of fuels are shown.

Compound	Molar mass / g mol^{-1}	Density at STP / g dm^{-3}	$\Delta H_c / \text{kJ mol}^{-1}$	Energy density at STP / kJ dm^{-3}	Specific energy / kJ g^{-1}
Hydrogen	2.02	0.0890	-286	12.6	141.6
Methane	16.05	0.707	-891	39.3	

(i) Calculate the specific energy, in kJ g^{-1} , of methane.

[1]

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(ii) Comment on the specific energies of hydrogen and methane.

[1]

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(Option C continues on the following page)



(Option C, question 10 continued)

- (c) Calculate the mass, in kg, of carbon dioxide produced by the complete combustion of 72.0 dm³ octane, C₈H₁₈.

Density of C₈H₁₈ = 703 g dm⁻³



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- 11.** Solar energy, which is freely available, is indispensable to life on earth.

- (a) Suggest another advantage and one disadvantage of solar energy. [2]

Advantage:

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Disadvantage:

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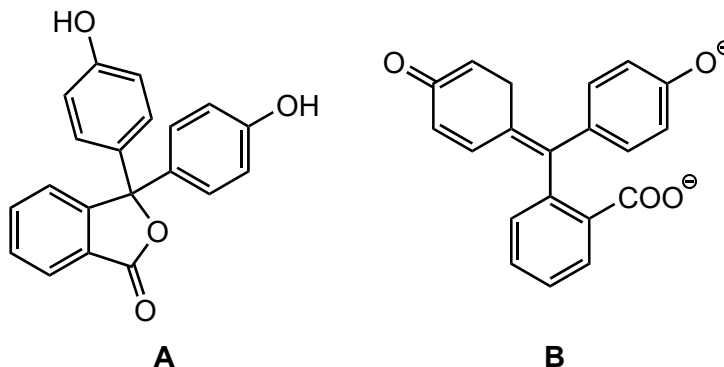
(Option C continues on the following page)



(Option C, question 11 continued)

- (b) Light can be absorbed by chlorophyll and other pigments.

Consider molecules **A** and **B** represented below.



Identify, with a reason, the molecule that absorbs visible light.

[1]

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- (c) (i) State a physical property of vegetable oils that makes them very difficult to use as fuel in internal combustion engines.

[1]

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- (ii) Describe how vegetable oils can be converted to a more suitable fuel.

[1]

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(Option C continues on the following page)



(Option C, question 11 continued)

(d) Contrast the importance of carbon dioxide and methane as greenhouse gases. [2]

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(e) Explain, using an equation, the effect of increased carbon dioxide in the atmosphere on the pH of lake water. [2]

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End of Option C



Option D — Medicinal chemistry

12. The structure of penicillin is shown in section 37 of the data booklet.

- (a) State the internal bond angles in the β -lactam ring and the expected bond angles for the same atoms in an open structure. [2]

	Bond angle
β -lactam ring
Expected bond angles

- (b) Explain how the open β -lactam ring kills bacteria. [2]

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- (c) Outline **one** effect of over-prescription of penicillin. [1]

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- (d) State how the structure of penicillin can be changed to combat this effect. [1]

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(Option D continues on the following page)



(Option D, question 12 continued)

(e) Suggest why human cells are not affected by penicillin. [1]

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13. Opiates are strong analgesics.

(a) Explain why diamorphine (heroin) crosses the blood-brain barrier more easily than morphine. [2]

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(b) Describe the analgesic action of an opiate. [1]

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(c) Outline the meaning of the bioavailability of a drug. [1]

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Option D continues on the following page)



(Option D continued)

14. Buffer systems control pH in the body.

- (a) Determine the pH of a buffer solution that is $0.0100 \text{ mol dm}^{-3}$ sodium hydrogen carbonate and $0.0200 \text{ mol dm}^{-3}$ sodium carbonate, using section 1 of the data booklet.

K_a (hydrogen carbonate ion) = 4.8×10^{-11} [2]

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- (b) State the equation for the reaction of calcium carbonate, the active ingredient in some antacids, with stomach acid. [1]

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- (c) Suggest a technique for measuring the percentage mass of calcium carbonate in this type of antacid tablet. [1]

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(Option D continues on the following page)



(Option D, continued)

15. Viruses and bacteria both cause diseases and are frequently confused.

(a) State **one** way in which viruses differ from bacteria.

[1]

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(b) Outline **two** different ways in which antiviral medications work.

[2]

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16. Suggest **two** reasons why chlorinated solvents should neither be released into the atmosphere nor incinerated (burnt).

[2]

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End of Option D



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