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MINDFLEX
HOME TUITION

Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Standard level
Paper 2

Monday 14 November 2016 (morning)

Candidate session number

1 hour 15 minutes

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Write your answers in the 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 **[50 marks]**.

8816–6105

Answer **all** questions. Write your answers in the boxes provided.

1. Ethane-1,2-diol, $HOCH_2CH_2OH$, has a wide variety of uses including the removal of ice from aircraft and heat transfer in a solar cell.

(a) Ethane-1,2-diol can be formed according to the following reaction.

$$2CO(g) + 3H_2(g) \rightleftharpoons HOCH_2CH_2OH(g)$$

(i) Deduce the equilibrium constant expression, K_c, for this reaction. [1]

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(ii) State how increasing the pressure of the reaction mixture at constant temperature will affect the position of equilibrium and the value of K_c. [2]

Position of equilibrium:

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K_c:

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(iii) Calculate the enthalpy change, $\Delta H^{\ominus}$, in kJ, for this reaction using section 11 of the data booklet. The bond enthalpy of the carbon–oxygen bond in CO(g) is $1077\,kJ\,mol^{-1}$. [3]

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(This question continues on the following page)

(Question 1 continued)

(iv) The enthalpy change, $\Delta H^{\ominus}$, for the following similar reaction is –233.8 kJ.

$$2CO(g) + 3H_2(g) \rightleftharpoons HOCH_2CH_2OH(l)$$

Deduce why this value differs from your answer to (a)(iii). [1]

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(b) Determine the average oxidation state of carbon in ethene and in ethane-1,2-diol. [2]

Ethene:

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Ethane-1,2-diol:

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(c) Explain why the boiling point of ethane-1,2-diol is significantly greater than that of ethene. [2]

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(d) Ethane-1,2-diol can be oxidized first to ethanedioic acid, $(COOH)_2$, and then to carbon dioxide and water. Suggest the reagents to oxidize ethane-1,2-diol. [1]

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2. The concentration of a solution of a weak acid, such as ethanedioic acid, can be determined by titration with a standard solution of sodium hydroxide, NaOH (aq).

(a) Distinguish between a weak acid and a strong acid. [1]

Weak acid:

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Strong acid:

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(b) Suggest why it is more convenient to express acidity using the pH scale instead of using the concentration of hydrogen ions. [1]

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(c) 5.00 g of an impure sample of hydrated ethanedioic acid, $(COOH)_2 \bullet 2H_2O$, was dissolved in water to make 1.00 dm^3 of solution. 25.0 cm^3 samples of this solution were titrated against a 0.100 mol dm^{-3} solution of sodium hydroxide using a suitable indicator.

$$(COOH)_2(aq) + 2NaOH(aq) \rightarrow (COONa)_2(aq) + 2H_2O(l)$$

The mean value of the titre was 14.0 cm^3.

(i) Calculate the amount, in mol, of NaOH in 14.0 cm^3 of 0.100 mol dm^{-3} solution. [1]

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(This question continues on the following page)

(Question 2 continued)

(ii) Calculate the amount, in mol, of ethanedioic acid in each 25.0 cm^3 sample. [1]

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(iii) Determine the percentage purity of the hydrated ethanedioic acid sample. [3]

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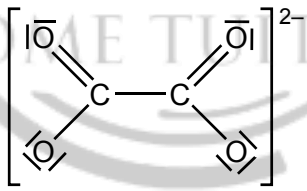
(d) The Lewis (electron dot) structure of the ethanedioate ion is shown below.



Outline why all the C–O bond lengths in the ethanedioate ion are the same length and suggest a value for them. Use section 10 of the data booklet. [2]

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will not be marked.

3. Sodium thiosulfate solution reacts with dilute hydrochloric acid to form a precipitate of sulfur at room temperature.

$$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow S(s) + SO_2(g) + 2NaCl(aq) + X$$

(a) Identify the formula and state symbol of X. [1]

. . . . . .

(b) Suggest why the experiment should be carried out in a fume hood or in a well-ventilated laboratory. [1]

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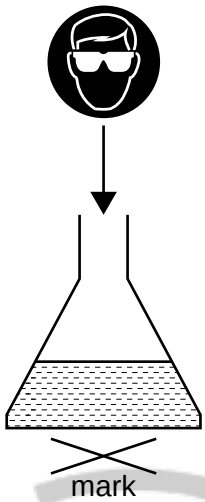
(This question continues on the following page)

(Question 3 continued)

(c) The precipitate of sulfur makes the mixture cloudy, so a mark underneath the reaction mixture becomes invisible with time.



10.0 cm^3 of 2.00 mol dm^{-3} hydrochloric acid was added to a 50.0 cm^3 solution of sodium thiosulfate at temperature, T_1. Students measured the time taken for the mark to be no longer visible to the naked eye. The experiment was repeated at different concentrations of sodium thiosulfate.

Experiment	$[Na_2S_2O_3(aq)]$ / mol dm^{-3}	Time, t, for mark to disappear / s $\pm$ 1 s	$\frac{1}{t}$* / 10^{-3} s^{-1}
1	0.150	23	43.5
2	0.120	27	37.0
3	0.090	36	27.8
4	0.060	60	16.7
5	0.030	111	9.0

* The reciprocal of the time in seconds can be used as a measure of the rate of reaction.

[Source: Adapted from http://www.flinnsci.com/]

Show that the hydrochloric acid added to the flask in experiment 1 is in excess. [2]

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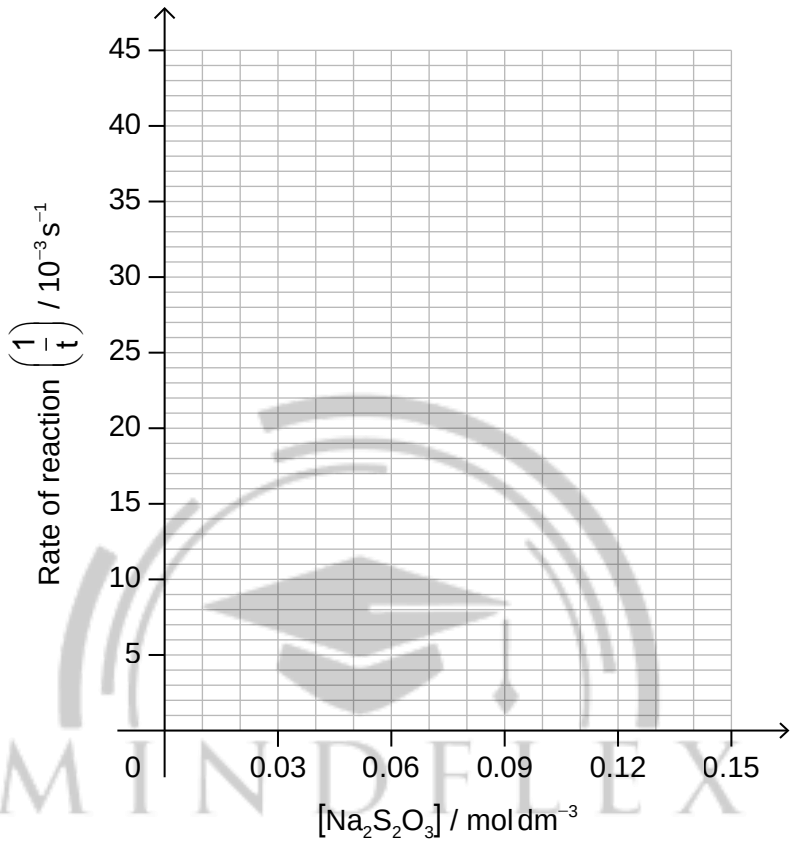
(Question 3 continued)

(d) Draw the best fit line of $\frac{1}{t}$ against concentration of sodium thiosulfate on the axes provided. [2]



(e) A student decided to carry out another experiment using 0.075 mol dm^{-3} solution of sodium thiosulfate under the same conditions. Determine the time taken for the mark to be no longer visible. [2]

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(This question continues on the following page)

(Question 3 continued)

(f) An additional experiment was carried out at a higher temperature, T_2.

(i) On the same axes, sketch Maxwell–Boltzmann energy distribution curves at the two temperatures T_1 and T_2, where $T_2 > T_1$. [2]

(ii) Explain why a higher temperature causes the rate of reaction to increase. [2]

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(g) Suggest one reason why the values of rates of reactions obtained at higher temperatures may be less accurate. [1]

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(This question continues on the following page)

4. Magnesium is a group 2 metal which exists as a number of isotopes and forms many compounds.

(a) State the nuclear symbol notation, ${}^{A}_{Z}X$, for magnesium-26. [1]

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(b) Mass spectroscopic analysis of a sample of magnesium gave the following results:

	% abundance
Mg-24	78.60
Mg-25	10.11
Mg-26	11.29

Calculate the relative atomic mass, A_r, of this sample of magnesium to two decimal places. [2]

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(c) Magnesium burns in air to form a white compound, magnesium oxide. Formulate an equation for the reaction of magnesium oxide with water. [1]

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(This question continues on the following page)

(Question 4 continued)

(d) Describe the trend in acid-base properties of the oxides of period 3, sodium to chlorine. [2]

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(e) In addition to magnesium oxide, magnesium forms another compound when burned in air. Suggest the formula of this compound. [1]

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(f) Describe the structure and bonding in solid magnesium oxide. [2]

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(g) Magnesium chloride can be electrolysed.

Deduce the half-equations for the reactions at each electrode when **molten** magnesium chloride is electrolysed, showing the state symbols of the products. The melting points of magnesium and magnesium chloride are 922 K and 987 K respectively. [2]

Anode (positive electrode):

. . . . . .

Cathode (negative electrode):

. . . . . .

5. Propane and propene are members of different homologous series.

(a) Draw the full structural formulas of propane and propene. [1]

Propane:

Propene:

(b) Both propane and propene react with bromine.

(i) State an equation and the condition required for the reaction of 1 mol of propane with 1 mol of bromine. [2]

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(ii) State an equation for the reaction of 1 mol of propene with 1 mol of bromine. [1]

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(This question continues on the following page)

(Question 5 continued)

(iii) State the type of each reaction with bromine. [1]

Propane:

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Propene:

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Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Standard level
Paper 3

Tuesday 15 November 2016 (morning)

Candidate session number

1 hour

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 – 2

Section B	Questions
Answer all of the questions from one of the options.	
Option A — Materials	3 – 7
Option B — Biochemistry	8 – 10
Option C — Energy	11 – 15
Option D — Medicinal chemistry	16 – 20

30 pages

8816 – 6106

Section A

Answer **all** questions. Write your answers in the boxes provided.

1. In order to provide safe drinking water, a water supply is often treated with disinfectants, which aim to inactivate disease-causing bacteria in the water.

To compare the effectiveness of different disinfectants, a **CT value** is used as a measure of the dosage of disinfectant needed to achieve a certain level of inactivation of specific bacteria.

CT value ($mg\,min\,dm^{-3}$) = C ($mg\,dm^{-3}$) concentration of disinfectant × T (min) contact time with water

(a) The table below compares the CT values of different disinfectants necessary to achieve 99 % inactivation of two types of bacteria, listed as **A** and **B**.

Disinfectant	**CT value / $mg\,min\,dm^{-3}$ for 99 % inactivation of bacteria**	
	Bacterium A	**Bacterium B**
Hypochlorous acid, HOCl	4×10^{-2}	8×10^{-2}
Hypochlorite ion, OCl^-	9.2×10^{-1}	3.3
Chlorine dioxide, ClO_2	1.8×10^{-1}	1.3×10^{-1}
Monochloramine, NH_2Cl	64	94

(i) Deduce the oxidation state of chlorine in the following disinfectants. [1]

HOCl:

. . . . . .

ClO_2:

. . . . . .

(This question continues on the following page)

(Question 1 continued)

(ii) From the data on CT values, justify the statement that bacterium **B** is generally more resistant to disinfection than bacterium **A**. [1]

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(iii) CT values can be used to determine whether a particular treatment process is adequate. Calculate the CT value, in $mg\,min\,dm^{-3}$, when $1.50 \times 10^{-5}\,g\,dm^{-3}$ of chlorine dioxide is added to a water supply with a contact time of 9.82 minutes. [1]

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(iv) From your answer to (a) (iii) and the data in the table, comment on whether this treatment will be sufficient to inactivate 99 % of bacterium **A**. [1]

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(This question continues on the following page)

(Question 1 continued)

(b) CT values are influenced by temperature and by pH. The table below shows the CT values for chlorine needed to achieve 99 % inactivation of a specific bacterium at stated values of pH and temperature.

pH	Temperature / °C				
	0.5	**5.0**	**10.0**	**15.0**	**20.0**
6.0	97	69	52	35	26
7.0	137	97	73	49	37
8.0	197	140	105	70	53
9.0	281	201	151	101	75

(i) With reference to the temperature data in the table, suggest why it may be more difficult to treat water effectively with chlorine in cold climates. [1]

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(ii) Sketch a graph on the axes below to show how the CT value (at any temperature) varies with pH. [1]

(This question continues on the following page)

(Question 1 continued)

(iii) Comment on the relative CT values at pH 6.0 and pH 9.0 at each temperature. [1]

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(iv) Chlorine reacts with water as follows:

$$Cl_2(g) + H_2O(l) \rightleftharpoons HOCl(aq) + HCl(aq)$$

$$HOCl(aq) \rightleftharpoons OCl^-(aq) + H^+(aq)$$

Predict how the concentrations of each of the species $HOCl(aq)$ and $OCl^-(aq)$ will change if the pH of the disinfected water increases. [1]

$HOCl(aq)$:

. . . . . .

$OCl^-(aq)$:

. . . . . .

(c) Despite widespread improvements in the provision of safe drinking water, the sale of bottled water has increased dramatically in recent years. State one problem caused by this trend. [1]

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2. In a class experiment, students were asked to determine the value of **x** in the formula of a hydrated salt, $BaCl_2 \cdot \mathbf{x}H_2O$. They followed these instructions:

1. Measure the mass of an empty crucible and lid.
2. Add approximately 2 g sample of hydrated barium chloride to the crucible and record the mass.
3. Heat the crucible using a Bunsen burner for five minutes, holding the lid at an angle so gas can escape.
4. After cooling, reweigh the crucible, lid and contents.
5. Repeat steps 3 and 4.

Their results in three trials were as follows:

	Trial 1	**Trial 2**	**Trial 3**
Mass of crucible + lid / g ±0.001	20.088	20.122	20.105
Mass of crucible + lid + $BaCl_2 \cdot \mathbf{x}H_2O$ before heating / g ±0.001	22.166	22.184	22.186
Mass of crucible + lid + $BaCl_2$ after 1st heating / g ±0.001	21.859	22.080	21.926
Mass of crucible + lid + $BaCl_2$ after 2nd heating / g ±0.001	21.859	21.865	21.927

(a) State and explain the further work students need to carry out in trial 2 before they can process the results alongside trial 1. [2]

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(b) In trial 3, the students noticed that after heating, the crucible had turned black on the outside. Suggest what may have caused this, and how this might affect the calculated value for **x** in the hydrated salt. [2]

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(This question continues on the following page)

(Question 2 continued)

(c) List **two** assumptions made in this experiment. [2]

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Section B

Answer **all** of the questions from **one** of the options.

Option A — Materials

3. Materials science involves understanding the properties of materials and applying those properties to desired structures.

(a) Magnesium oxide, MgO, and silicon carbide, SiC, are examples of ceramic materials. State the name of the predominant type of bonding in each material. [1]

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(b) Predict the predominant type of bonding for a binary compound AB in which the electronegativity of both atoms is low. Use section 29 of the data booklet. [1]

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4. A student wanted to determine the formula of indium sulfate. She applied an electrical current of 0.300 A to an aqueous solution of indium sulfate for 9.00×10^3 s and found that 1.07 g of indium metal deposited on the cathode.

(a) Calculate the charge, in coulombs, passed during the electrolysis. [1]

$$\left(\text{current } I = \frac{\text{charge } Q}{\text{time } t}\right)$$

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(Option A continues on the following page)

(Option A, question 4 continued)

(b) Calculate the amount, in mol, of electrons passed using section 2 of the data booklet. [1]

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(c) Calculate the mass of indium deposited by one mole of electrons. [1]

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(d) Calculate the number of moles of electrons required to deposit one mole of indium.
Relative atomic mass of indium, $A_r = 114.82$. [1]

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(e) Deduce the charge on the indium ion and the formula of indium sulfate. [1]

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(Option A continues on the following page)

(Option A continued)

5. Research has led to the discovery of new catalysts that are in high demand and used in many chemical industries.

(a) Explain, with reference to their structure, the great selectivity of zeolites as catalysts. [2]

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(b) Nanocatalysts play an essential role in the manufacture of industrial chemicals.

(i) Describe the high pressure carbon monoxide (HIPCO) method for the production of carbon nanotubes. [2]

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(ii) Outline one benefit of using nanocatalysts compared to traditional catalysts in industry. [1]

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(Option A continues on the following page)

(Option A continued)

6. Polymers are made up of repeating monomer units which can be manipulated in various ways to give structures with desired properties.

(a) (i) Draw the structure of 2-methylpropene. [1]

(ii) Deduce the repeating unit of poly(2-methylpropene). [1]

(b) Deduce the percentage atom economy for polymerization of 2-methylpropene. [1]

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(c) (i) Suggest why incomplete combustion of plastic, such as polyvinyl chloride, is common in industrial and house fires. [1]

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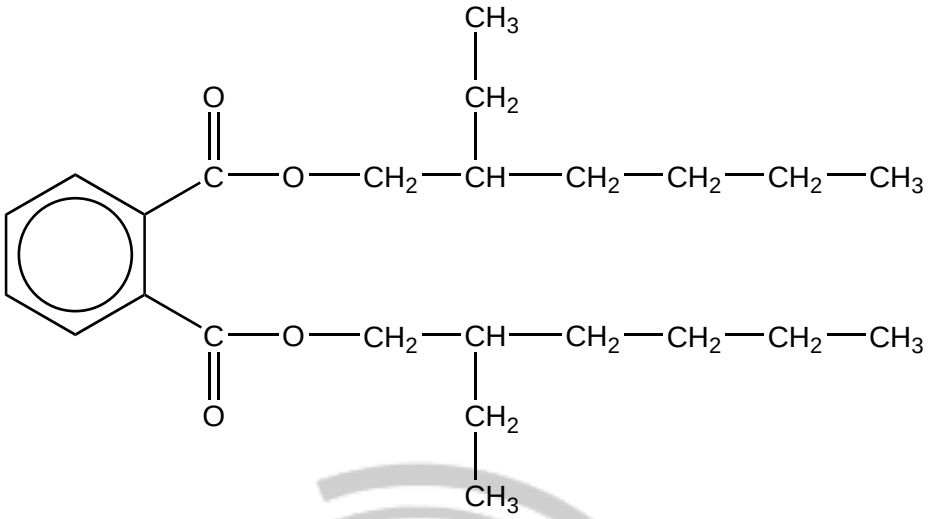
(Option A continues on the following page)

(Option A, question 6 continued)

(ii) Phthalate plasticizers such as DEHP, shown below, are frequently used in polyvinyl chloride.



With reference to bonding, suggest a reason why many adults have measurable levels of phthalates in their bodies. [1]

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7. Liquid crystals have many applications.

(a) Outline how a lyotropic liquid crystal differs from a thermotropic liquid crystal. [2]

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(Option A continues on the following page)

(Option A, question 7 continued)

(b) Explain the effect of increasing the temperature of a nematic liquid crystal on its directional order. [1]

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End of Option A

Option B — Biochemistry

8. Lipids are an important part of the human diet.

(a) Fatty acids react with glycerol to form fats and oils. State the name of the chemical link formed in this reaction and the name of the other product. [1]

Name of the chemical link:

. . . . . .

Name of the other product:

. . . . . .

(b) The table below shows average figures for the percentage fatty acid composition of some common fats and oils.

Source of fat or oil	% saturated fatty acids (total)	% monounsaturated fatty acid oleic	% polyunsaturated fatty acids	
			linoleic	linolenic
Beef fat	59	38	3	-
Coconut oil	90	8	2	-
Corn oil	25	26	47	2
Cotton seed oil	22	35	43	-
Olive oil	15	78	7	-
Soybean oil	14	28	50	8

(i) Deduce, with a reason, which fat or oil from the table above has the lowest iodine number. [1]

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(ii) Deduce, with a reason, which fat or oil from the table above is most likely to become rancid when exposed to the air. [1]

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(Option B continues on the following page)

(Option B, question 8 continued)

(iii) The **P/S index** of a fat or oil is the ratio of polyunsaturated fat to saturated fat present. It is sometimes used to compare the relative health benefits of different lipids in the diet. Calculate the P/S index of beef fat and soybean oil. [1]

Beef fat:

. . . . . .

Soybean oil:

. . . . . .

(iv) Suggest why a P/S index of greater than 1 is considered beneficial to health. [1]

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(v) Cotton seed oil and corn oil have similar iodine numbers but the melting point of cotton seed oil is higher than that of corn oil. Suggest an explanation in terms of the structure and bonding in these two oils. [2]

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(Option B continues on the following page)

(Option B continued)

9. Carbohydrates are energy-rich molecules which can be synthesized in some plant cells from inorganic compounds.

(a) State the raw materials and source of energy used in the process described above. [1]

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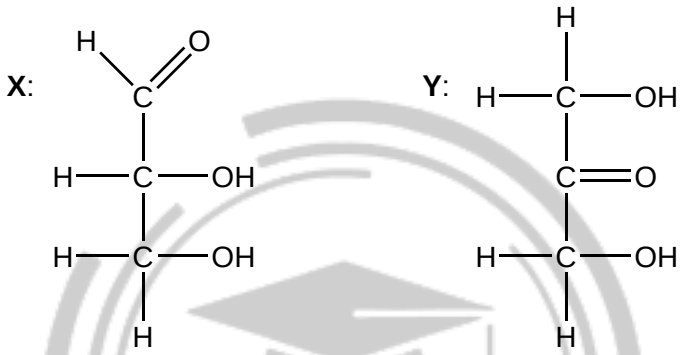
(b) The structures of two molecules, **X** and **Y**, are shown below.



(i) Justify why both these molecules are carbohydrates. [1]

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(ii) Distinguish between these molecules in terms of their functional groups. [1]

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(Option B continues on the following page)

(Option B, question 9 continued)

(c) Amylose is an unbranched polysaccharide composed of repeating units of glucose.

(i) Draw the structure of the repeating unit of amylose. Use section 34 of the data booklet. [1]

(ii) Amylose is a major component of starch. Corn starch can be used to make replacements for plastics derived from oil, especially for packaging. Discuss **one** potential advantage and **one** disadvantage of this use of starch. [2]

Advantage:

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Disadvantage:

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(Option B continues on the following page)

(Option B continued)

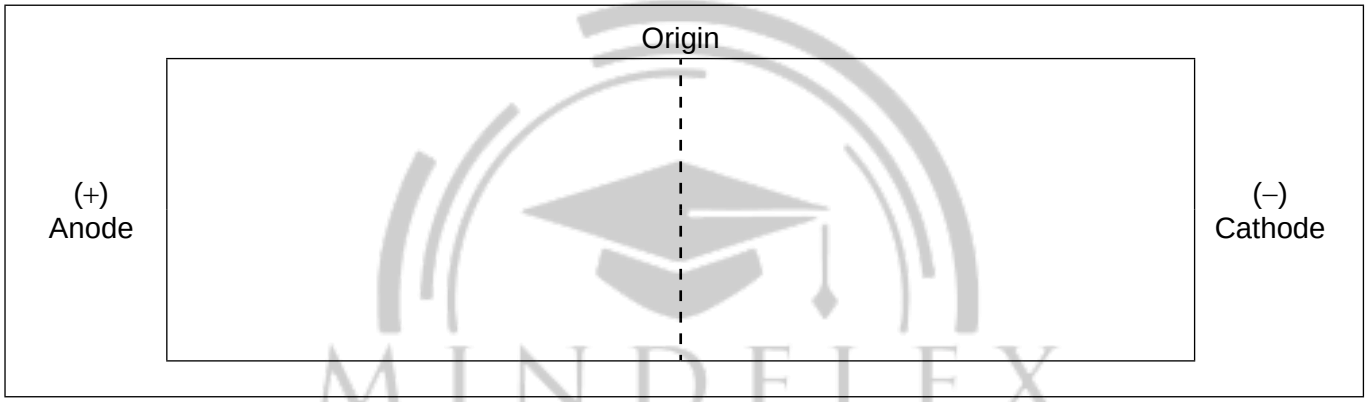
10. Amino acids are usually identified by their common names. Use section 33 of the data booklet.

(a) State the IUPAC name for leucine. [1]

. . . . . .

(b) A mixture of amino acids is separated by gel electrophoresis at pH 6.0. The amino acids are then stained with ninhydrin.

(i) On the diagram below draw the relative positions of the following amino acids at the end of the process: Val, Asp, Lys and Thr. [2]



(ii) Suggest why glycine and isoleucine separate slightly at pH 6.5. [1]

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(c) Determine the number of different tripeptides that can be made from twenty different amino acids. [1]

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(Option B continues on the following page)

(Option B, question 10 continued)

(d) The fibrous protein keratin has a secondary structure with a helical arrangement.

(i) State the type of interaction responsible for holding the protein in this arrangement. [1]

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(ii) Identify the functional groups responsible for these interactions. [1]

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End of Option B

Option C — Energy

11. Chemical energy from redox reactions can be used as a portable source of electrical energy. A hybrid car uses a lithium ion battery in addition to gasoline as fuel.

(a) (i) Calculate the specific energy of the lithium ion battery, in $MJ\,kg^{-1}$, when 80.0 kg of fuel in the battery releases 1.58×10^7 J. Use section 1 of the data booklet. [1]

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(ii) The specific energy of gasoline is $46.0\,MJ\,kg^{-1}$. Suggest why gasoline may be considered a better energy source than the lithium ion battery based on your answer to part (a) (i). [1]

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(b) (i) The energy density of gasoline is $34.3\,MJ\,dm^{-3}$. Calculate the volume of gasoline, in dm^3, that is equivalent to the energy in 80.0 kg of fuel in the lithium ion battery. Use section 1 of the data booklet. [1]

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(ii) The efficiency of energy transfer by this lithium ion battery is four times greater than that of gasoline. Determine the distance, in km, the car can travel on the lithium ion battery power alone if the gasoline-powered car uses $1.00\,dm^3$ gasoline to travel 32.0 km. [1]

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(Option C continues on the following page)

(Option C continued)

12. Auto-ignition of hydrocarbon fuel in a car engine causes “knocking”. The tendency of a fuel to knock depends on its molecular structure.

(a) Discuss how the octane number changes with the molecular structure of the alkanes. [2]

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(b) Catalytic reforming and cracking reactions are used to produce more efficient fuels. Deduce the equation for the conversion of heptane to methylbenzene. [1]

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13. Carbon dioxide and water vapour are greenhouse gases produced by the combustion of fossil fuels.

(a) Explain the effect of the increasing concentration of atmospheric carbon dioxide on the acidity of oceans. [2]

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(Option C continues on the following page)

(Option C, question 13 continued)

(b) (i) Describe the changes that occur at the molecular level when atmospheric carbon dioxide gas absorbs infrared radiation emitted from the Earth's surface. [2]

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(ii) Other than changes to the acidity of oceans, suggest why the production of carbon dioxide is of greater concern than the production of water vapour. [1]

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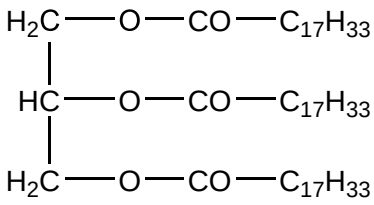
14. Biofuels are renewable energy sources derived mainly from plants.

(a) State the equation for the complete transesterification of the triglyceride given below with methanol. [2]



(Option C continues on the following page)

(Option C, question 14 continued)

(b) Outline why the fuel produced by the reaction in (a) is more suitable for use in diesel engines than vegetable oils. [1]

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15. Nuclear reactions transform one nuclide into another. Fission, splitting a large nucleus into two smaller nuclei, releases vast amounts of energy.

(a) (i) Explain why fusion, combining two smaller nuclei into a larger nucleus, releases vast amounts of energy. Use section 36 of the data booklet. [2]

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(ii) Outline **one** advantage of fusion as a source of energy. [1]

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(Option C continues on the following page)

(Option C, question 15 continued)

(b) Radioactive phosphorus, ^{33}P, has a half-life of 25.3 days.

(i) Calculate ^{33}P decay constant λ and state its unit. Use section 1 of the data booklet. [1]

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(ii) Determine the fraction of the ^{33}P sample remaining after 101.2 days. [1]

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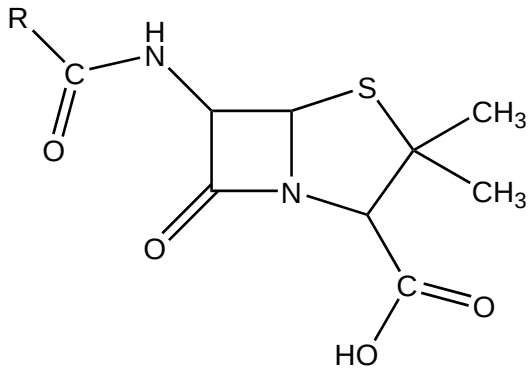
End of Option C

Option D — Medicinal chemistry

16. Penicillin is an antibiotic which contains a beta-lactam ring. Its general structure is shown below.



(a) (i) Outline what is meant by the term "ring strain". [1]

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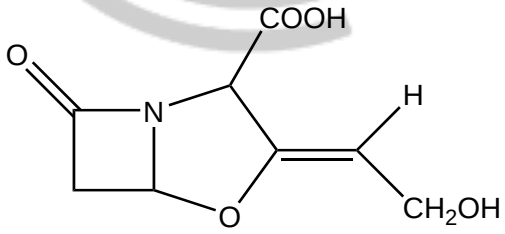
(ii) On the diagram above, label with asterisk/s (*) the carbon atom/s that experience ring strain. [1]

(b) (i) Some antibiotic-resistant bacteria produce a beta-lactamase enzyme which destroys penicillin activity. Suggest how adding clavulanic acid to penicillin enables the antibiotic to retain its activity. [1]



Clavulanic acid

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(Option D continues on the following page)

(Option D, question 16 continued)

(ii) Populations of antibiotic-resistant bacteria have increased significantly over the last 60 years. Outline why antibiotics such as penicillin should not be prescribed to people suffering from a viral infection. [2]

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17. Oseltamivir (Tamiflu) and zanamivir (Relenza) are both used as antivirals to help prevent the spread of the flu virus, but are administered by different methods.

(a) Zanamivir must be taken by inhalation, not orally. Deduce what this suggests about the bioavailability of zanamivir if taken orally. [1]

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(b) Oseltamivir does not possess the carboxyl group needed for activity until it is chemically changed in the body. Deduce the name of the functional group in oseltamivir which changes into a carboxyl group in the body. Use section 37 of the data booklet. [1]

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(c) The synthesis of oseltamivir is dependent on a supply of the precursor shikimic acid, which is available only in low yield from certain plants, notably Chinese star anise. State one alternative green chemistry source of shikimic acid. [1]

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(Option D continues on the following page)

(Option D continued)

18. The mild analgesic aspirin can be prepared in the laboratory from salicylic acid.

$$(CH_3CO)_2O + HOC_6H_4COOH \rightarrow CH_3CO_2C_6H_4COOH + CH_3COOH$$

Salicylic acid Aspirin

After the reaction is complete, the product is isolated, recrystallized, tested for purity and the experimental yield is measured. A student's results in a single trial are as follows.

	Mass / g ±0.001	**Melting point / °C ±1**
Initial salicylic acid	1.552	
Crude product	1.398	106–114
Product after recrystallization	1.124	122–125

Literature melting point data: aspirin = 138–140 °C

(a) Determine the percentage experimental yield of the product after recrystallization. The molar masses are as follows: M(salicylic acid) = 138.13 g mol^{-1}, M(aspirin) = 180.17 g mol^{-1}. (You do not need to process the uncertainties in the calculation.) [2]

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(b) Suggest why isolation of the crude product involved the addition of ice-cold water. [1]

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(Option D continues on the following page)

(Option D, question 18 continued)

(c) Justify the conclusion that recrystallization increased the purity of the product, by reference to **two** differences between the melting point data of the crude and recrystallized products. [2]

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(d) State why aspirin is described as a mild analgesic with reference to its site of action. [1]

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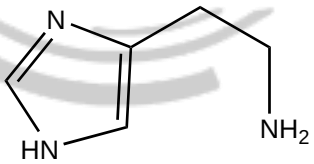
19. Excess stomach acid leads to medical conditions that affect many people worldwide. These conditions can be treated with several types of medical drugs.

(a) Ranitidine (Zantac) is a drug that inhibits stomach acid production. Outline why the development of this drug was based on a detailed knowledge of the structure of histamine, shown below. [1]



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(Option D continues on the following page)

(Option D, question 19 continued)

(b) Two other drugs, omeprazole (Prilosec) and esomeprazole (Nexium), directly prevent the release of acid into the stomach. Identify the site of action in the body. [1]

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(c) A different approach to treating excess stomach acid is to neutralize it with antacids. Formulate an equation that shows the action of an antacid that can neutralize three moles of hydrogen ions, H^+, per mole of antacid. [1]

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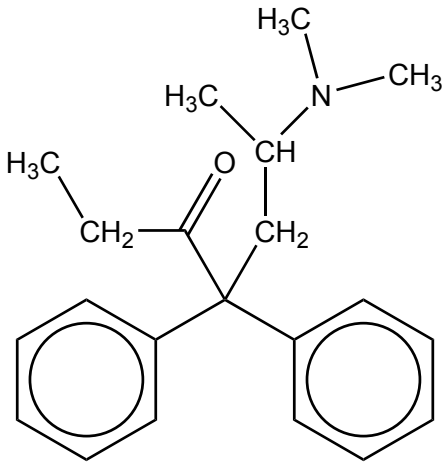
(Option D continues on the following page)

(Option D continued)

20. Methadone, a synthetic opioid, binds to opioid receptors in the brain.



Methadone

(a) Compare and contrast the functional groups present in methadone and diamorphine (heroin), giving their names. Use section 37 of the data booklet. [2]

One similarity:

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One difference:

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(b) Methadone is sometimes used to help reduce withdrawal symptoms in the treatment of heroin addiction. Outline **one** withdrawal symptom that an addict may experience. [1]

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End of Option D

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