Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Standard level
Paper 3

Thursday 23 May 2019 (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 – 5
Option B — Biochemistry	6 – 8
Option C — Energy	9 – 13
Option D — Medicinal chemistry	14 – 17

2219 – 6118

23 pages

Section A

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

1. This question is about a mug made of a lead alloy.

The rate of lead dissolving in common beverages with various pH values was analysed.

Lead dissolving in beverages at various times and temperatures

Experiment	Beverage	pH	Time / min	Temp. / °C	Lead concentration / mg dm^{-3}
1	Cola	2.5	5	16	6
2	Cola	2.5	30	16	14
3	Cola	2.5	60	16	23
4	Cola	2.5	5	18	11
5	Lemonade	2.9	5	18	14
6	Orange juice	3.7	5	18	18
7	Beer	4.2	5	18	2.3
8	Tap water	5.9	5	18	15

[Source: first published in *Chemistry in Australia*, chemaust.raci.org.au]

(This question continues on the following page)

(Question 1 continued)

(a) Identify the experiment with the highest rate of lead dissolving. [1]

. . . . . .

(b) (i) Suggest why the relationship between time and lead concentration for Cola at 16 °C is not linear. [1]

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(ii) Examine, giving a reason, whether the rate of lead dissolving increases with acidity at 18 °C. [1]

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(c) (i) Lead(II) chloride, $PbCl_2$, has very low solubility in water.

$$PbCl_2(s) \rightleftharpoons Pb^{2+}(aq) + 2Cl^-(aq)$$

Explain why the presence of chloride ions in beverages affects lead concentrations. [2]

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(This question continues on the following page)

(Question 1 continued)

(ii) A mean daily lead intake of greater than 5.0×10^{-6} g per kg of body weight results in increased lead levels in the body.

Calculate the volume, in dm^3, of tap water from experiment 8 which would exceed this daily lead intake for an 80.0 kg man. [2]

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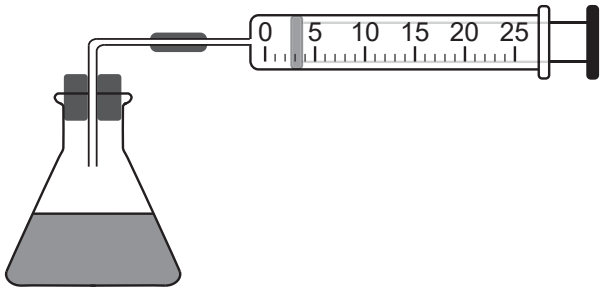
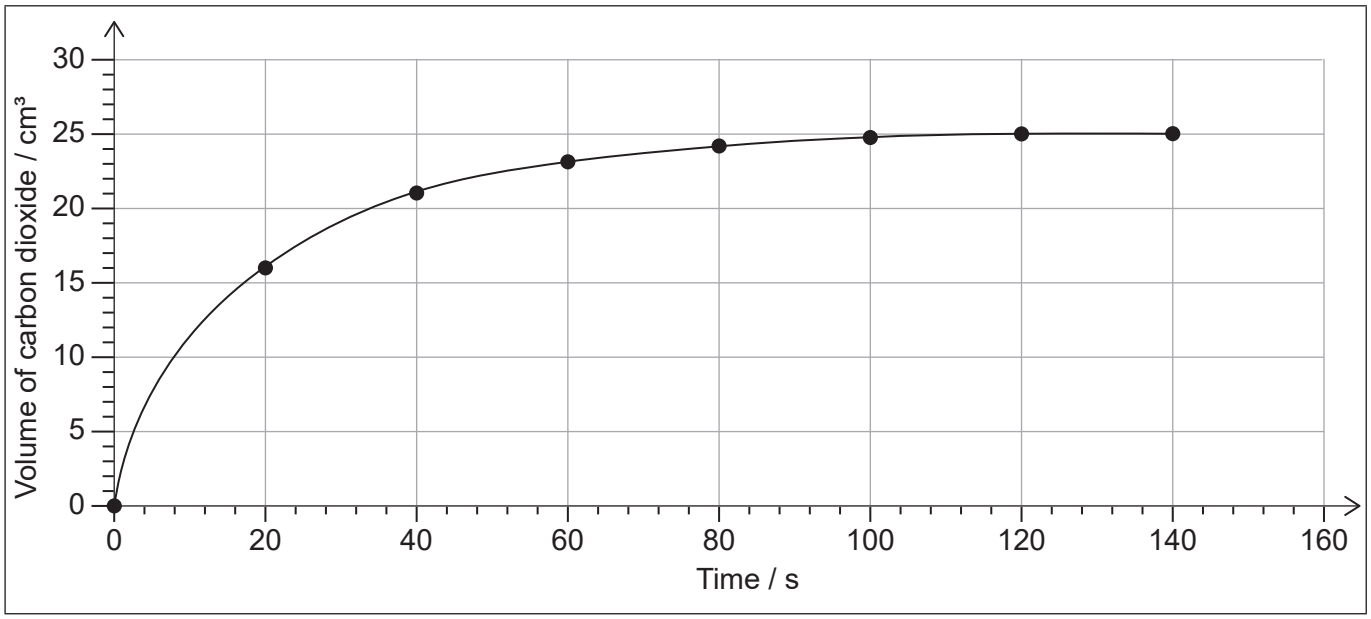
2. Bromine and methanoic acid react in aqueous solution.

$$Br_2(aq) + HCOOH(aq) \rightarrow 2Br^-(aq) + 2H^+(aq) + CO_2(g)$$

The reaction was monitored by measuring the volume of carbon dioxide produced as time progressed.



[Source: © International Baccalaureate Organization 2019]



[Source: © International Baccalaureate Organization 2019]

(This question continues on the following page)

(Question 2 continued)

(a) Determine from the graph the rate of reaction at 20 s, in $cm^3 s^{-1}$, showing your working. [3]

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(b) Outline, with a reason, another property that could be monitored to measure the rate of this reaction. [2]

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(c) (i) Describe **one** systematic error associated with the use of the gas syringe, and how the error affects the calculated rate. [2]

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(ii) Identify **one** error associated with the use of an accurate stopwatch. [1]

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Section B

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

Option A — Materials

3. Describe the characteristics of the nematic liquid crystal phase and the effect that an electric field has on it. [3]

Shape of molecules:

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Distribution:

. . . . . .

. . . . . .

Effect of electric field:

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4. Metals are extracted from their ores by several methods, including electrolysis and reduction with carbon.

(a) Determine the mass of aluminium, in g, that could be extracted from an appropriate solution by a charge of 48 250 C. Use sections 2 and 6 of the data booklet. [3]

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(Option A continues on the following page)

(Option A, question 4 continued)

(b) Once extracted, the purity of the metal can be assessed using ICP-MS. Suggest **two** advantages of using plasma technology rather than regular mass spectrometry. [2]

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(c) Explain the action of metals as heterogeneous catalysts. [2]

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(d) Outline how alloys conduct electricity and why they are often harder than pure metals. [2]

Conduct electricity:

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Harder than pure metals:

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(e) Carbon nanotubes are added to metals to increase tensile strength.

Write an equation for the formation of carbon nanotubes from carbon monoxide. [1]

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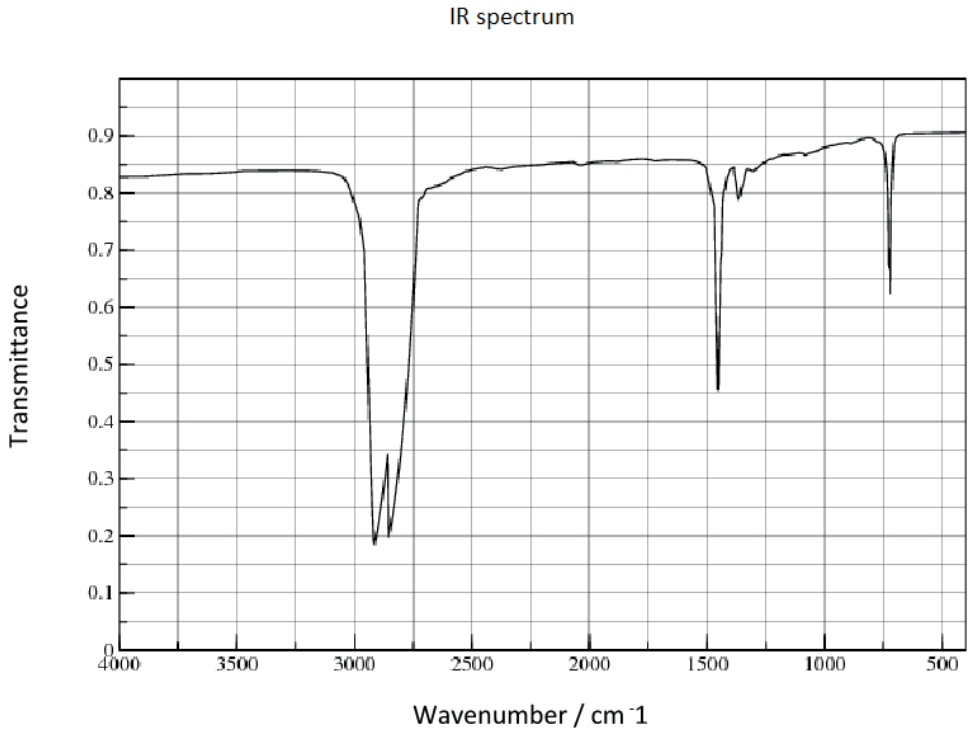
(Option A continues on the following page)

(Option A continued)

5. Polymers have a wide variety of uses but their disposal can be problematic.

(a) Draw a section of isotactic polychloroethene (polyvinylchloride, PVC) showing all the atoms and all the bonds of **four** monomer units. [2]

(b) The infrared (IR) spectrum of polyethene is given.



[Source: used with kind permission from Dr Aubrey Jaffer]

Suggest how the IR spectrum of polychloroethene would differ, using section 26 of the data booklet. [1]

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(Option A continues on the following page)

(Option A, question 5 continued)

(c) Identify a hazardous product of the incineration of polychloroethene. [1]

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(d) Explain how plasticizers affect the properties of plastics. [2]

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(e) Suggest why the addition of plasticizers is controversial. [1]

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End of Option A

Option B — Biochemistry

6. Proteins have structural or enzyme functions.

(a) (i) Some proteins form an α-helix. State the name of another secondary protein structure. [1]

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(ii) Compare and contrast the bonding responsible for the two secondary structures. [2]

One similarity:

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One difference:

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(b) Explain why an increase in temperature reduces the rate of an enzyme-catalyzed reaction. [2]

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(Option B continues on the following page)

(Option B, question 6 continued)

(c) Oil spills are a major environmental problem.

(i) Suggest **two** reasons why oil decomposes faster at the surface of the ocean than at greater depth. [2]

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(ii) Oil spills can be treated with an enzyme mixture to speed up decomposition.

Outline **one** factor to be considered when assessing the greenness of an enzyme mixture. [1]

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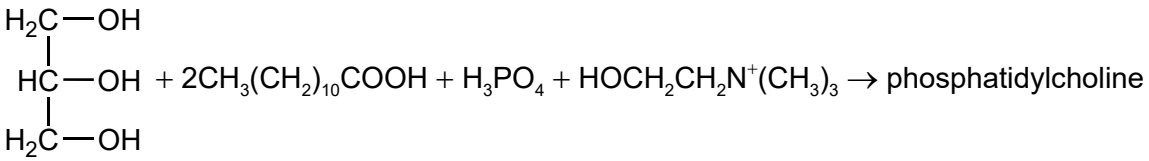
(Option B continues on the following page)

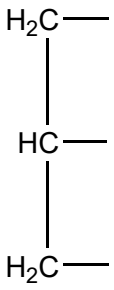
(Option B continued)

7. Phosphatidylcholine is an example of a phospholipid found in lecithin.

(a) Phosphatidylcholine may be formed from propane-1,2,3-triol, two lauric acid molecules, phosphoric acid and the choline cation.



(i) Deduce the structural formula of phosphatidylcholine. [2]



(ii) Identify the type of reaction in (a). [1]

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(b) Lecithin is a major component of cell membranes. Describe the structure of a cell membrane. [2]

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(Option B continues on the following page)

(Option B, question 7 continued)

(c) Predict, giving a reason, the relative energy density of a carbohydrate and a lipid of similar molar mass. [1]

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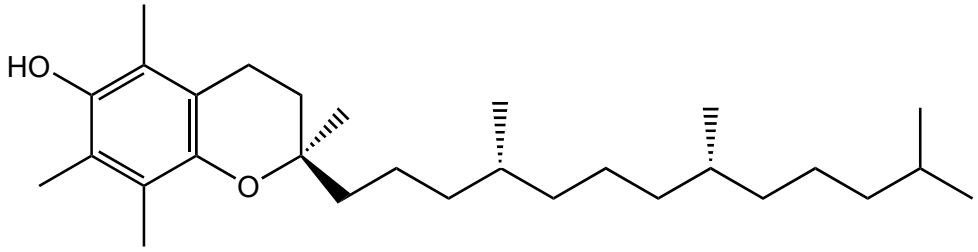
(d) Lecithin aids the body's absorption of vitamin E.



The α-tocopherol form of vitamin E.

Suggest why vitamin E is fat-soluble. [1]

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(e) Phospholipids are also found in lipoprotein structures.

Describe **two** effects of increased levels of low-density lipoprotein (LDL) on health. [2]

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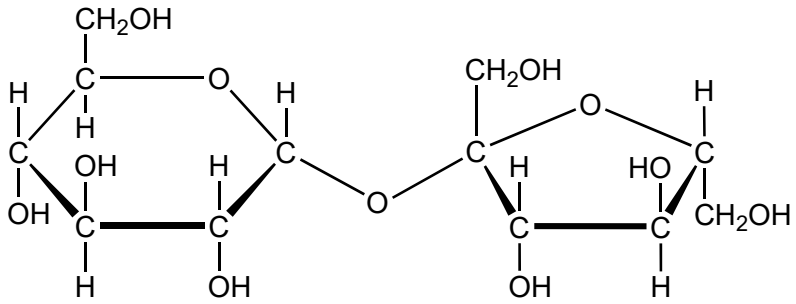
(Option B continues on the following page)

(Option B continued)

8. Sucrose is a disaccharide.



(a) State the name of the functional group forming part of the ring structure of each monosaccharide unit. [1]

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(b) Sketch the cyclic structures of the two monosaccharides which combine to form sucrose. [2]

End of Option B

Option C — Energy

9. The regular rise and fall of sea levels, known as tides, can be used to generate energy.

State **one** advantage, other than limiting greenhouse gas emissions, and **one** disadvantage of tidal power. [2]

Advantage:

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Disadvantage:

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10. This question is about fuel for engines.

(a) Crude oil can be converted into fuels by fractional distillation and cracking.

Contrast these two processes. [2]

Fractional distillation	Cracking
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(Option C continues on the following page)

(Option C, question 10 continued)

(b) Determine the specific energy, in $kJ\,g^{-1}$, and energy density, in $kJ\,cm^{-3}$, of hexane, C_6H_{14}. Give both answers to three significant figures.

Hexane: $M_r = 86.2$; $\Delta H_c = -4163\,kJ\,mol^{-1}$; density $= 0.660\,g\,cm^{-3}$ [2]

Specific energy:

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Energy density:

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(c) Hydrocarbons need treatment to increase their octane number to prevent pre-ignition (knocking) before they can be used in internal combustion engines.

Describe how this is carried out and the molecular changes that take place. [2]

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(Option C continues on the following page)

(Option C continued)

11. This question is about nuclear reactions.

(a) Fission of a nucleus can be initiated by bombarding it with a neutron.

(i) Determine the other product of the fission reaction of plutonium-239. [1]

$^{239}_{94}Pu + {}^{1}_{0}n \rightarrow {}^{134}_{54}Xe + \ldots\ldots\ldots\ldots\ldots + 3{}^{1}_{0}n$

(ii) Outline the concept of critical mass with respect to fission reactions. [1]

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(iii) Outline **one** advantage of allowing all countries access to the technology to generate electricity by nuclear fission. [1]

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(b) State **one** advantage of using fusion reactions rather than fission to generate electrical power. [1]

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(Option C continues on the following page)

(Option C, question 11 continued)

(c) ^{90}Sr, a common product of fission, has a half-life of 28.8 years.

Determine the number of years for the activity of a sample of ^{90}Sr to fall to one eighth ($\frac{1}{8}$) of its initial value. [1]

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12. This question is about biofuel.

(a) The structure of chlorophyll is given in section 35 of the data booklet.

State the feature of the chlorophyll molecule that enables it to absorb light in the visible spectrum. [1]

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(b) Evaluate the use of biodiesel in place of diesel from crude oil. [2]

Strength:

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Limitation:

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(Option C continues on the following page)

(Option C continued)

13. This question is about global warming.

(a) State **one** greenhouse gas, other than carbon dioxide. [1]

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(b) Describe the effect of infrared (IR) radiation on carbon dioxide molecules. [2]

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(c) Outline **one** approach to controlling industrial emissions of carbon dioxide. [1]

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End of Option C

Option D — Medicinal chemistry

14. Medicines and drugs are tested for effectiveness and safety.

(a) Distinguish between therapeutic window and therapeutic index in humans. [2]

Therapeutic window:

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Therapeutic index:

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(b) (i) State **one** advantage of using morphine as an analgesic. [1]

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(ii) Explain why diamorphine (heroin) is more potent than morphine using section 37 of the data booklet. [2]

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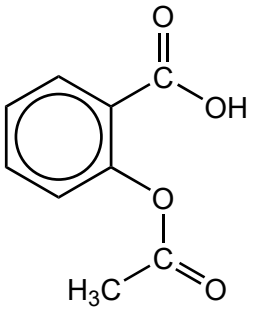
(Option D continues on the following page)

(Option D continued)

15. A student synthesized aspirin, acetylsalicylic acid, in a school laboratory.



Aspirin
$M_r = 180.17$

(a) Predict **one** absorption band present in an infrared (IR) spectrum of aspirin, using section 26 of the data booklet. [1]

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(b) 0.300 g of crude aspirin was dissolved in ethanol and titrated with sodium hydroxide solution, NaOH (aq).

$NaOH(aq) + C_9H_8O_4(\text{in ethanol}) \rightarrow NaC_9H_7O_4(aq) + H_2O(l)$

(i) Determine the mass of aspirin which reacted with 16.25 cm^3 of 0.100 mol dm^{-3} NaOH solution. [2]

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(ii) Determine the percentage purity of the synthesized aspirin. [1]

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(Option D continues on the following page)

(Option D, question 15 continued)

(c) Outline how aspirin can be chemically modified to increase its solubility in water. [1]

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(d) State why aspirin should not be taken with alcohol. [1]

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(e) Outline **two** factors which must be considered to assess the greenness of any chemical process. [2]

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16. Excess acid in the stomach can cause breakdown of the stomach lining.

(a) (i) Outline how ranitidine (Zantac) inhibits stomach acid production. [1]

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(ii) Outline **two** advantages of taking ranitidine instead of an antacid which neutralizes excess acid. [2]

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(Option D continues on the following page)

(Option D, question 16 continued)

(b) Some antacids contain carbonates.

Determine the pH of a buffer solution which contains 0.160 mol dm^{-3} CO_3^{2-} and 0.200 mol dm^{-3} HCO_3^-, using section 1 of the data booklet.

pK_a (HCO_3^-) = 10.32 [1]

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17. Antiviral medications have recently been developed for some viral infections.

(a) Outline **one** way in which antiviral drugs work. [1]

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(b) Discuss **two** difficulties associated with solving the AIDS problem. [2]

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End of Option D

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

Answers written on this page
will not be marked.