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# Chemistry

## Standard level

### Paper 3

Thursday 23 May 2019 (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 – 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



### 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 / $\text{mg dm}^{-3}$
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]

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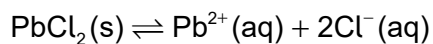
- (b) (i) Suggest why the relationship between time and lead concentration for Cola at 16 °C is not linear. [1]

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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<sub>2</sub>, has very low solubility in water.



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  $5.0 \times 10^{-6}$  g per kg of body weight results in increased lead levels in the body.

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

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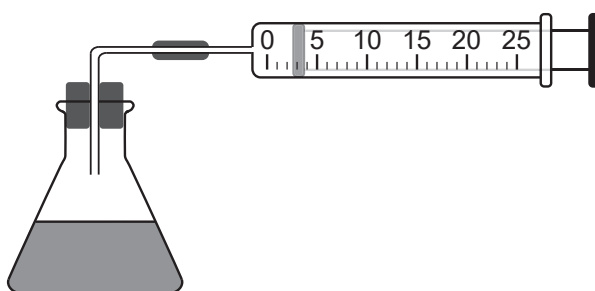
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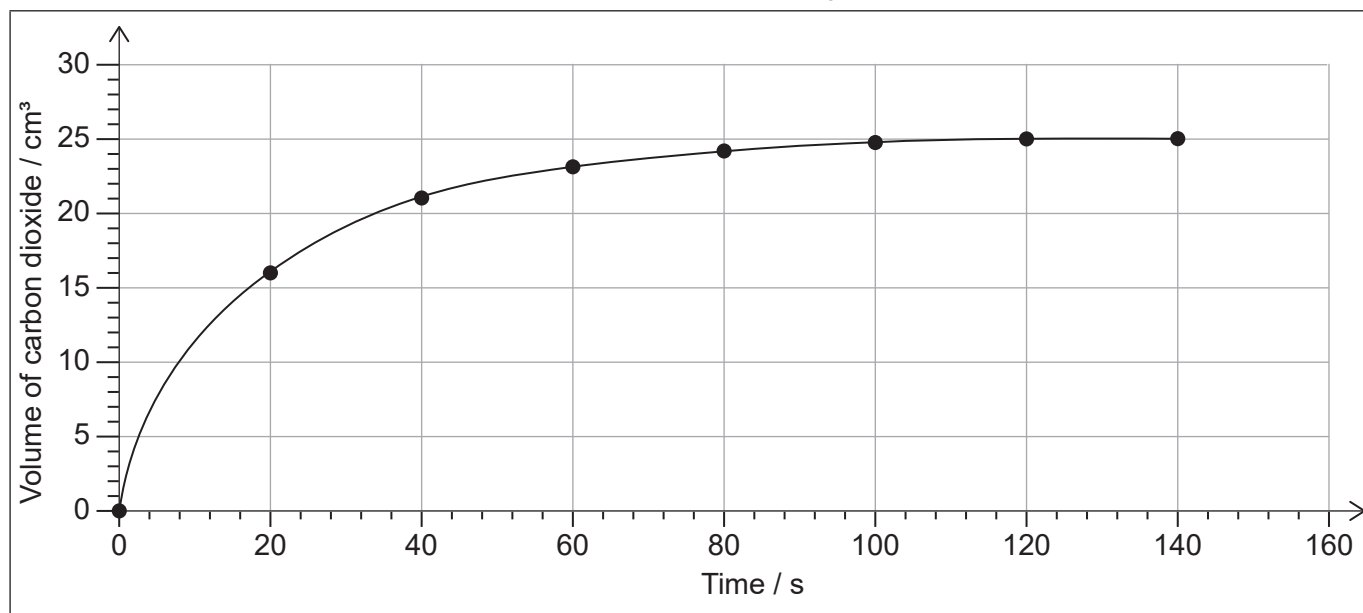
**2. Bromine and methanoic acid react in aqueous solution.**



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)**



24EP04

**(Question 2 continued)**

(a) Determine from the graph the rate of reaction at 20 s, in  $\text{cm}^3 \text{s}^{-1}$ , 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:  
.....

Distribution:  
.....  
.....

Effect of electric field:  
.....  
.....

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)**



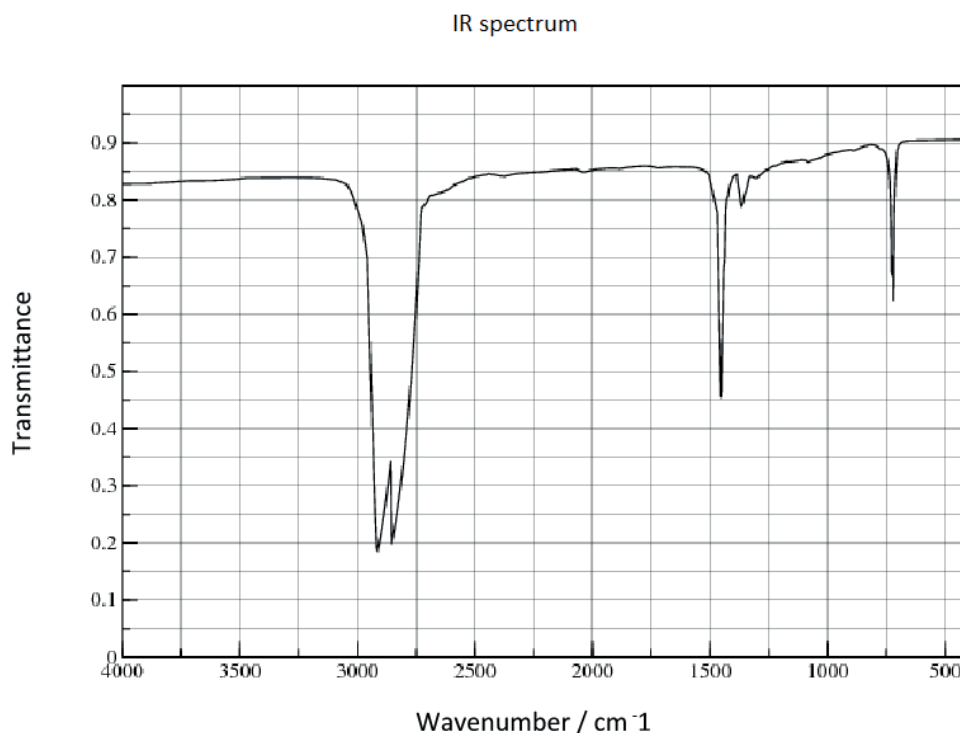


(Option A continued)

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]

.....

(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  $\alpha$ -helix. State the name of another secondary protein structure. [1]

.....

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

One similarity:

.....  
.....

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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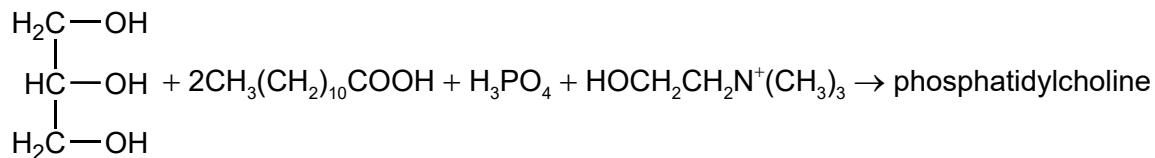
**(Option B continues on the following page)**



**(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]

$$\begin{array}{c}
 \text{H}_2\text{C}- \\
 | \\
 \text{HC}- \\
 | \\
 \text{H}_2\text{C}-
 \end{array}$$

(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)**

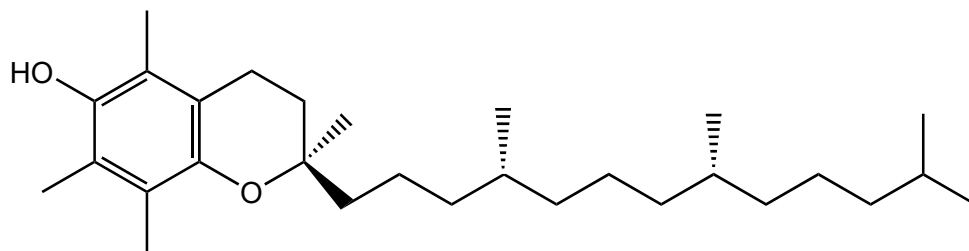


(Option B, question 7 continued)

- (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  $\alpha$ -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]

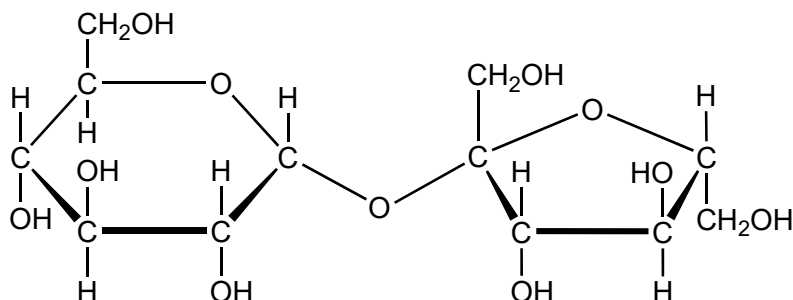
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(Option B continues on the following page)



**(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]

.....

(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]

<p>Advantage:</p> <p>.....</p> <p>.....</p> <p>Disadvantage:</p> <p>.....</p> <p>.....</p>
--

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
<p>.....</p> <p>.....</p> <p>.....</p>	<p>.....</p> <p>.....</p> <p>.....</p>
<p>.....</p> <p>.....</p> <p>.....</p>	<p>.....</p> <p>.....</p> <p>.....</p>

(Option C continues on the following page)





**(Option C, question 10 continued)**

- (b) Determine the specific energy, in  $\text{kJg}^{-1}$ , and energy density, in  $\text{kJcm}^{-3}$ , of hexane,  $\text{C}_6\text{H}_{14}$ . Give both answers to three significant figures.

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

[2]

Specific energy:

.....  
.....

Energy density:

.....  
.....

- (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)**

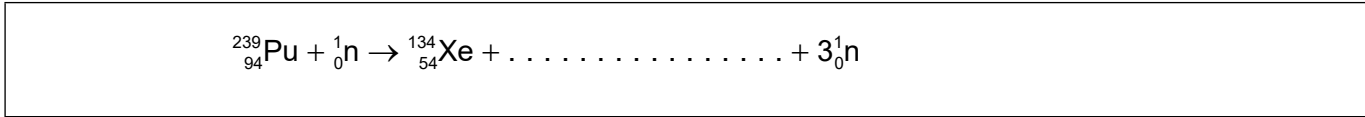


**(Option C continued)**

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]



(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)  $^{90}\text{Sr}$ , 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  $^{90}\text{Sr}$  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]

.....

.....

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

Strength:

.....

.....

Limitation:

.....

.....

**(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]

.....

(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:

.....  
.....  
.....

Therapeutic index:

.....  
.....  
.....

(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]

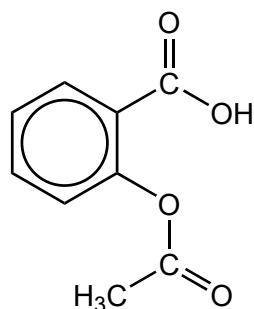
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**(Option D continues on the following page)**



(Option D continued)

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



Aspirin  
 $M_r = 180.17$

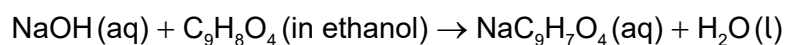
(a) Predict **one** absorption band present in an infrared (IR) spectrum of aspirin, using section 26 of the data booklet.

[1]

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.....

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



(i) Determine the mass of aspirin which reacted with 16.25 cm<sup>3</sup> of 0.100 mol dm<sup>-3</sup> NaOH solution.

[2]

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(ii) Determine the percentage purity of the synthesized aspirin.

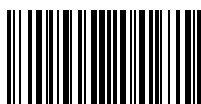
[1]

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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  $0.160 \text{ mol dm}^{-3} \text{ CO}_3^{2-}$  and  $0.200 \text{ mol dm}^{-3} \text{ HCO}_3^-$ , using section 1 of the data booklet.

$\text{p}K_a (\text{HCO}_3^-) = 10.32$

[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.

