Diploma Programme
Programme du diplôme
Programa del Diploma

**Chemistry
Standard level
Paper 3**

Thursday 9 November 2017 (morning)

1 hour

Candidate session number

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 – 3

Section B	Questions
Answer all of the questions from one of the options.	
Option A — Materials	4 – 7
Option B — Biochemistry	8 – 11
Option C — Energy	12 – 15
Option D — Medicinal chemistry	16 – 21

27 pages

28EP01

International Baccalaureate
Baccalauréat International
Bachillerato Internacional

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

Answers written on this page
will not be marked.

Section A

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

1. A student set up a simple voltaic cell consisting of a copper electrode and a zinc electrode dipped in sodium chloride solution.
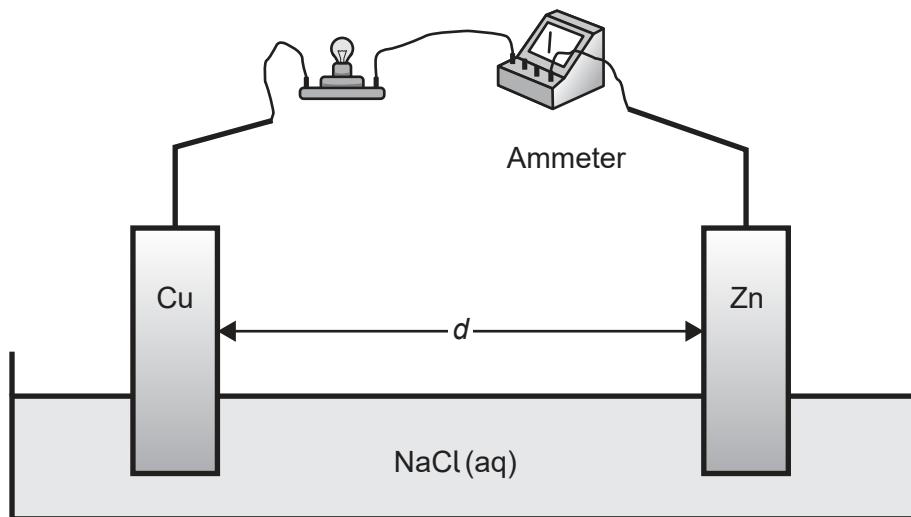
The student gradually increased the distance, d, between the electrodes to study the effect on the initial current, I, passing through the light bulb.

The student hypothesized that the initial current would be inversely proportional to the distance between the electrodes.

(a)   Sketch a graph that would support the student's hypothesis.   [1]
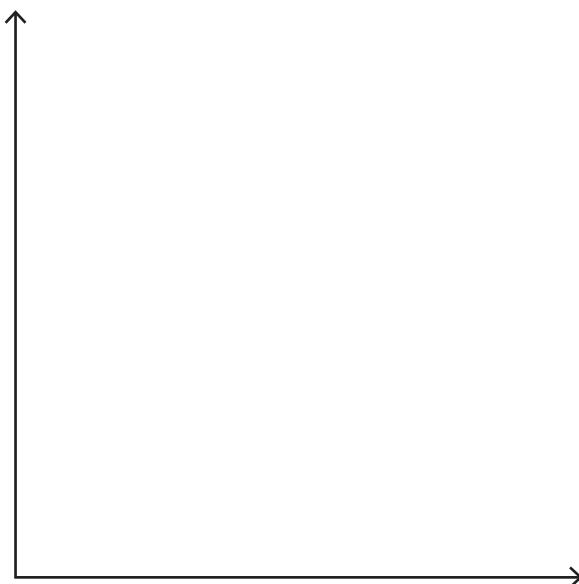
(This question continues on the following page)

Turn over

(Question 1 continued)

(b)   The following data was collected over five trials.

d / ±0.1 cm	Average I / ±0.04 A
4.0	0.093
10.0	0.083
16.0	0.073
20.0	0.067
26.0	0.057

The data did not support the student's hypothesis. He investigated other possible relationships by plotting a graph of the average current against the distance between the electrodes. He obtained the following best-fit line with a correlation coefficient (r) of −0.9999.
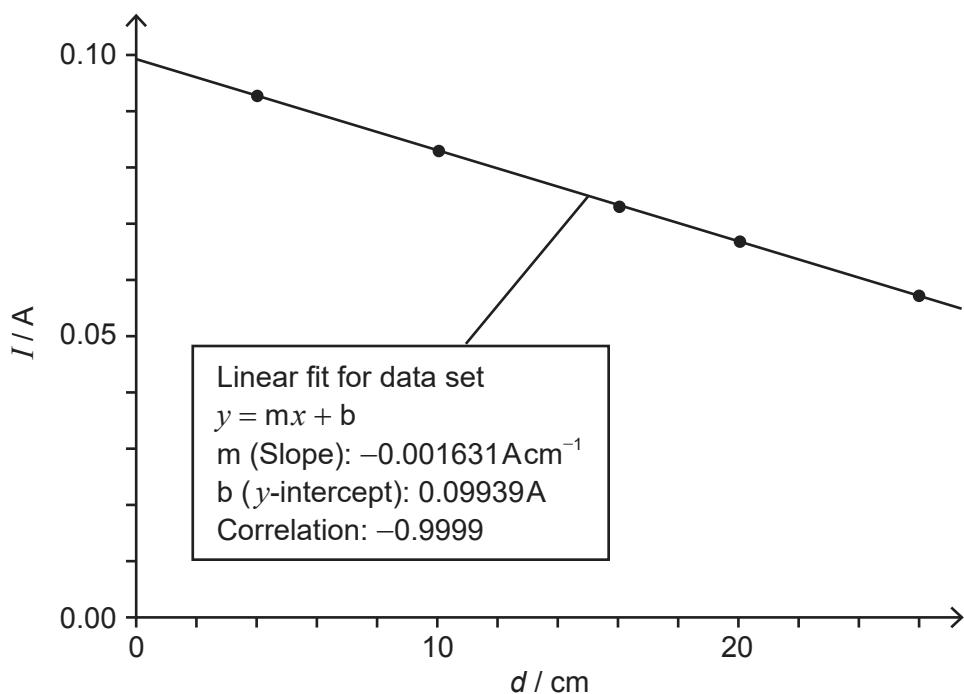
(i)   Suggest what the correlation coefficient of −0.9999 indicates.   [1]

....

....

(This question continues on the following page)

(Question 1 continued)

(ii) State the equation of the straight line obtained using the data. [1]

....

....

(iii) Outline how current flows in the sodium chloride solution. [1]

....

....

2.   Antacids react with hydrochloric acid in the stomach to relieve indigestion. A student investigated different brands of antacid to see which caused the largest increase in pH in a given time. She added the antacids to hydrochloric acid, and recorded the change in pH over five minutes.

Antacid brand	Active ingredient(s)	Recommended dosage	Dose used	Initial pH ±0.02	Final pH ±0.02	Change in pH
A	magnesium hydroxide aluminium hydroxide	2–3 tablets	2 tablets	1.68	4.53	+2.85
B	sodium hydrogen carbonate calcium carbonate	2–4 tablets	2 tablets	1.70	5.31	+3.61
C	calcium carbonate	1–2 tablets	1 tablet	1.70	4.52	+2.82
D	magnesium hydroxide aluminium oxide aluminium hydroxide	1–2 tablets	1 tablet	1.69	2.21	+0.52

(a)   State an equation for the reaction of magnesium hydroxide with hydrochloric acid.   [1]

....

(This question continues on the following page)

(Question 2 continued)

(b) Suggest two variables, besides the time of reaction, which the student should have
     controlled in the experiment to ensure a fair comparison of the antacids.   [2]

. . . .

. . . .

. . . .

. . . .

(c) Calculate the uncertainty in the change in pH.   [1]

. . . .

(d) The student concluded that antacid **B** was the most effective, followed by **A** then **C** and
     finally **D**. Discuss two arguments that reduce the validity of the conclusion.   [2]

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

3. Sodium chloride, NaCl, can be spread on icy roads to lower the freezing point of water. The diagram shows the effects of temperature and percentage by mass of NaCl on the composition of a mixture of NaCl and H_2O.
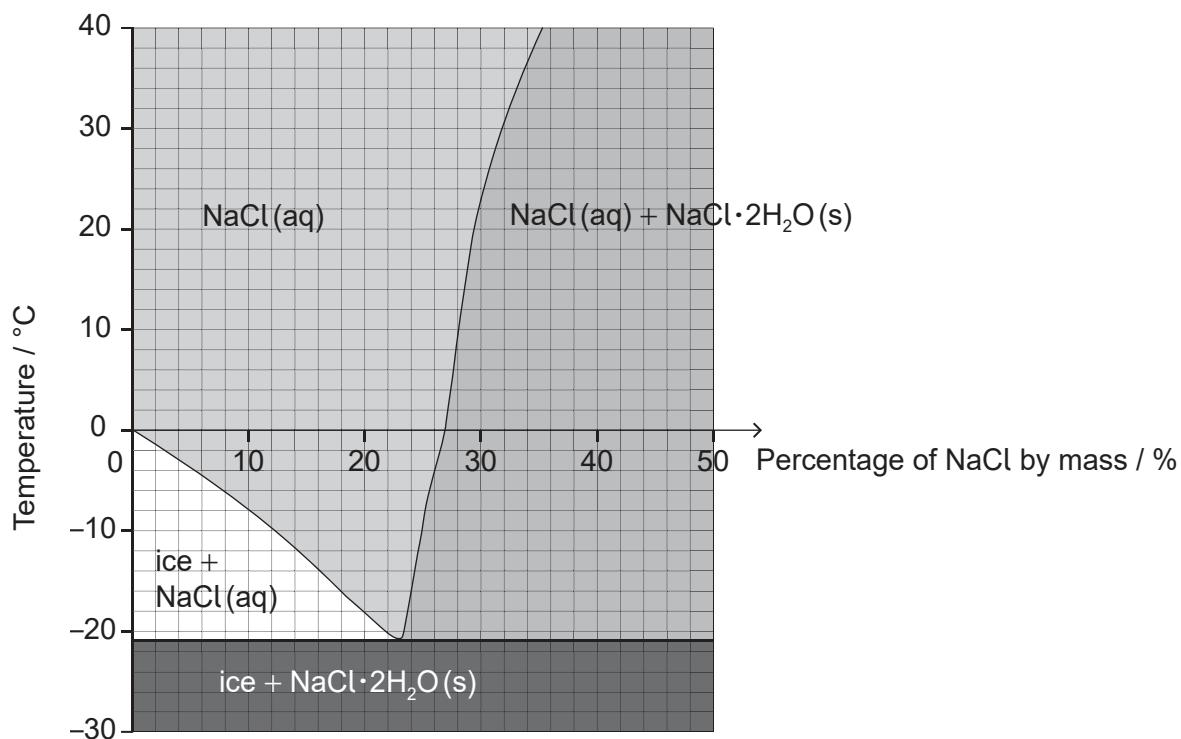
(a) Estimate the lowest freezing point of water that can be reached by adding sodium chloride. [1]

....

(b) Estimate the percentage by mass of NaCl dissolved in a saturated sodium chloride solution at $+10\,°C$. [1]

....

(This question continues on the following page)

(Question 3 continued)

(c)   Calculate the percentage of water by mass in the $NaCl \cdot 2H_2O$ crystals. Use the data from section 6 of the data booklet and give your answer to two decimal places.   [2]

. . . .

. . . .

. . . .

. . . .

(d)   Suggest a concern about spreading sodium chloride on roads.   [1]

. . . .

. . . .

Turn over

Section B

Answer **all** of the questions from **one** of the options. Write your answers in the boxes provided.

Option A — Materials

4. It is wise to fill dental cavities before irreversible tooth decay sets in. An amalgam (alloy of mercury, silver, and other metals) is often used although many prefer a white composite material.

    (a) Outline the composition of an alloy and a composite. [2]

    Alloy:

    ....

    ....

    Composite:

    ....

    ....

    (b) (i) Outline why an alloy is usually harder than its components by referring to its structure. [1]

    ....

    ....

    ....

    (ii) At present, composite fillings are more expensive than amalgam fillings. Suggest why a patient might choose a composite filling. [1]

    ....

    ....

(Option A continues on the following page)

(Option A, question 4 continued)

(c)   Explain how Inductively Coupled Plasma (ICP) Spectroscopy could be used to determine the concentration of mercury in a sample of dental filling.   [3]

....

....

....

....

....

....

....

....

5.   Catalysts can take many forms and are used in many industrial processes.

Suggest two reasons why it might be worth using a more expensive catalyst to increase the rate of a reaction.   [2]

....

....

....

....

(Option A continues on the following page)

(Option A continued)

6. Nanotechnology has many applications.

(a) State equations for the formation of iron nanoparticles and carbon atoms from $Fe(CO)_5$ in the HIPCO process. [2]

(b) Outline why the iron nanoparticle catalysts produced by the HIPCO process are more efficient than solid iron catalysts. [1]

(c) Discuss one possible risk associated with the use of nanotechnology. [1]

(Option A continues on the following page)

(Option A continued)

7. The development of materials with unique properties is critical to advances in industry.

    (a) Outline two properties a substance should have to be used as liquid-crystal in a
         liquid-crystal display.   [2]

    (b) Low density polyethene (LDPE) and high density polyethene (HDPE) are both addition
         polymers.

         (i) Describe how the structures of LDPE and HDPE affect one mechanical property
              of the plastics.   [2]

(Option A continues on the following page)

Turn over

(Option A, question 7 continued)

       (ii)   One of the two infrared (IR) spectra is that of polyethene and the other of polytetrafluoroethene (PTFE).

Removed for copyright reasons

(Option A continues on the following page)

(Option A, question 7 continued)

Deduce, with a reason, which spectrum is that of PTFE. Infrared data is given in section 26 of the data booklet.   [1]

. . . .

. . . .

. . . .

. . . .

(c)   Many plastics used to be incinerated. Deduce an equation for the complete combustion of two repeating units of PVC, $(-C_2H_3Cl-)_2$.   [2]

. . . .

. . . .

. . . .

. . . .

End of Option A

Option B — Biochemistry

8. Consider the following lipid and carbohydrate.

$CH_3(CH_2)_4(CH=CHCH_2)_2(CH_2)_6COOH$

Linoleic acid, M_r = 280.50
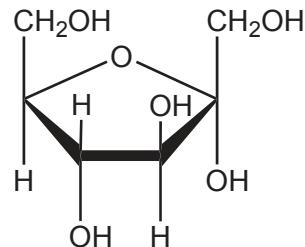
Fructose, M_r = 180.18

(a) (i) Determine the empirical formula of linoleic acid. [1]

....

....

   (ii) The empirical formula of fructose is CH_2O. Suggest why linoleic acid releases more energy per gram than fructose. [1]

....

....

....

(b) In order to determine the number of carbon-carbon double bonds in a molecule of linoleic acid, 1.24 g of the lipid were dissolved in 10.0 cm³ of non-polar solvent. The solution was titrated with a 0.300 mol dm⁻³ solution of iodine, I_2.

   (i) State the type of reaction occurring during the titration. [1]

....

(Option B continues on the following page)

(Option B, question 8 continued)

      (ii)   Calculate the volume of iodine solution used to reach the end-point.   [3]

    (c)   Outline the importance of linoleic acid for human health.   [2]

(Option B continues on the following page)

(Option B continued)

9. Lactose is a disaccharide formed by the condensation reaction of the monosaccharides galactose and glucose.
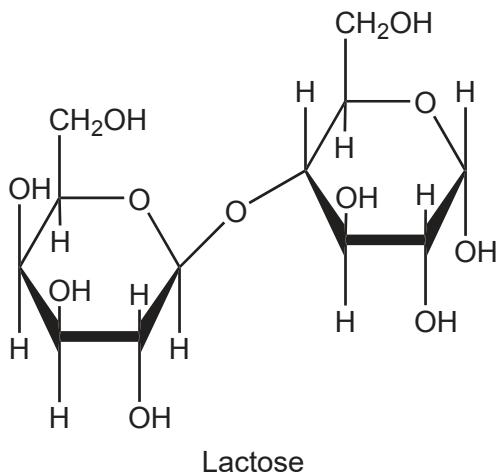
Lactose

(a) Describe what is meant by a condensation reaction. [2]

. . . .

. . . .

. . . .

. . . .

(b) Draw the structure of galactose on the skeleton provided. [1]
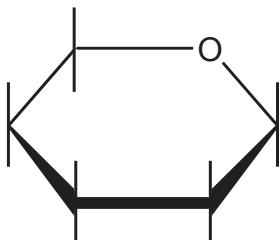
(Option B continues on the following page)

(Option B, question 9 continued)

    (c)   Explain how the inclusion of carbohydrates in plastics makes them biodegradable. [2]

10. Vitamins can be water-soluble or fat-soluble.

    (a)   Explain, at the molecular level, why vitamin D is soluble in fats. Use section 35 of the data booklet. [2]

    (b)   State **one** function of vitamin D in the body. [1]

(Option B continues on the following page)

Turn over

(Option B continued)

11. Enzyme activity depends on many factors. Explain how pH change causes loss of activity of
an enzyme. [4]

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

End of Option B

Option C — Energy

12. One method of comparing fuels is by considering their specific energies.

(a) Calculate the specific energy of octane, C_8H_{18}, in kJ kg^{-1} using sections 1, 6 and 13 of the data booklet. [2]

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

(b) A typical wood has a specific energy of 17×10^3 kJ kg^{-1}. Comment on the usefulness of octane and wood for powering a moving vehicle, using your answer to (a).
If you did not work out an answer for (a), use 45×10^3 kJ kg^{-1} but this is not the correct answer. [1]

....
....

(c) State the name of **one** renewable source of energy other than wood. [1]

....

(Option C continues on the following page)

(Option C continued)

13. Much of our energy needs are still provided by the refined products of crude oil.

(a) "Knocking" in an automobile (car) engine can be prevented by increasing the octane number of the fuel. Explain, including an equation with structural formulas, how heptane, C_7H_{16}, could be chemically converted to increase its octane number. [3]

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(b) Many like to refer to our "carbon footprint". Outline one difficulty in quantifying such a concept. [1]

. . . .

. . . .

. . . .

(c) Climate change or global warming is a consequence of increased levels of carbon dioxide in the atmosphere. Explain how the greenhouse effect warms the surface of the earth. [3]

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(Option C continues on the following page)

(Option C, question 13 continued)

(d)   Outline how water and carbon dioxide absorb infrared radiation.   [1]

....

....

14. In the 20th Century, both fission and fusion were considered as sources of energy but fusion was economically and technically unattainable.

(a)   (i)   Compare and contrast fission and fusion in terms of binding energy and the types of nuclei involved.   [2]

....

....

....

....

(ii)   Suggest **two** advantages that fusion has over fission.   [2]

....

....

....

....

(b)   The amount of ^{228}Ac in a sample decreases to one eighth $\left(\dfrac{1}{8}\right)$ of its original value in about 18 hours due to β-decay. Estimate the half-life of ^{228}Ac.   [1]

....

....

....

(Option C continues on the following page)

Turn over

(Option C continued)

15. Vegetable oils can be used as a source of energy.

(a) State the structural feature of chlorophyll that enables it to absorb visible light. [1]

....

....

(b) Vegetable oils are too viscous for use as liquid fuels. Describe, using an equation, how a vegetable oil, such as that shown, is converted to oils with lower viscosity by reaction with methanol, CH_3OH. [2]

$$H_2C-O-\overset{\displaystyle O}{\overset{\|}{C}}-(CH_2)_6CH_3$$

$$HC-O-\overset{\displaystyle O}{\overset{\|}{C}}-(CH_2)_6CH_3$$

$$H_2C-O-\overset{\displaystyle O}{\overset{\|}{C}}-(CH_2)_6CH_3$$
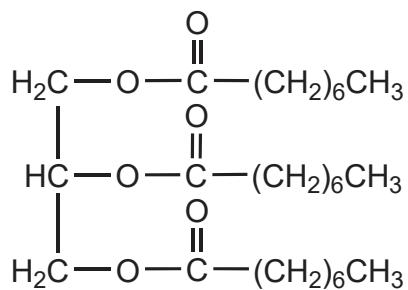
End of Option C

Option D — Medicinal chemistry

16. Radioisotopes are used to diagnose and treat various diseases. Explain the low environmental impact of most medical nuclear waste.   [2]

. . . .

. . . .

. . . .

. . . .

17. Some analgesics are derived from compounds found in plants.

(a) Aspirin is a mild analgesic derived from salicylic acid found in willow bark. Describe how mild analgesics function.   [2]

. . . .

. . . .

. . . .

. . . .

(b) (i) The strong analgesics morphine and codeine are opiates. Outline how codeine can be synthesized from morphine. The structures of morphine and codeine are in section 37 of the data booklet.   [1]

. . . .

. . . .

(ii) Explain why opiates are addictive.   [2]

. . . .

. . . .

. . . .

. . . .

. . . .

(Option D continues on the following page)

Turn over

(Option D continued)

18. New drugs undergo thorough clinical trials before they are approved.

(a) Outline the difference between the therapeutic index in animal studies and the therapeutic index in humans. [1]

....

....

(b) State the method of drug administration that gives the maximum bioavailability. [1]

....

19. Oseltamivir (Tamiflu) and zanamivir (Relenza) are antiviral drugs used to prevent flu.

(a) State the names of **two** functional groups that **both** compounds contain, using section 37 of the data booklet. [2]

....

....

....

(b) Explain how oseltamivir and zanamivir can stop the spread of the flu virus in the body. [2]

....

....

....

....

(Option D continues on the following page)

(Option D continued)

20.   Excess acid in the stomach can cause discomfort and more serious health issues.

      (a)   Explain how ranitidine (Zantac) reduces stomach acid production.   [2]

      ....

      ....

      ....

      ....

      (b)   The pH is maintained in different fluids in the body by the use of buffers.

            Calculate the pH of a buffer solution of $0.0200\,mol\,dm^{-3}$ carbonic acid, H_2CO_3, and $0.400\,mol\,dm^{-3}$ sodium hydrogen carbonate, $NaHCO_3$. The pK_a of carbonic acid is 6.35.   [2]

      ....

      ....

      ....

      ....

21.   Molecules of antibiotics often contain a beta-lactam ring. Explain the importance of the beta-lactam ring in the action of penicillin, using section 37 of the data booklet.   [3]

      ....

      ....

      ....

      ....

      ....

      ....

End of Option D

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

Answers written on this page
will not be marked.