22106118

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CHEMISTRY
STANDARD LEVEL
PAPER 3

Thursday 13 May 2010 (morning)

1 hour

Candidate session number

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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.
- Answer all of the questions from two of the Options in the spaces provided. You may continue your answers on answer sheets. Write your session number on each answer sheet, and attach them to this examination paper and your cover sheet using the tag provided.
- At the end of the examination, indicate the letters of the Options answered in the candidate box on your cover sheet and indicate the number of answer sheets used in the appropriate box on your cover sheet.

0124

Option A — Modern analytical chemistry

A1. State **two** reasons for the use of analytical techniques in today's society. *[2]*

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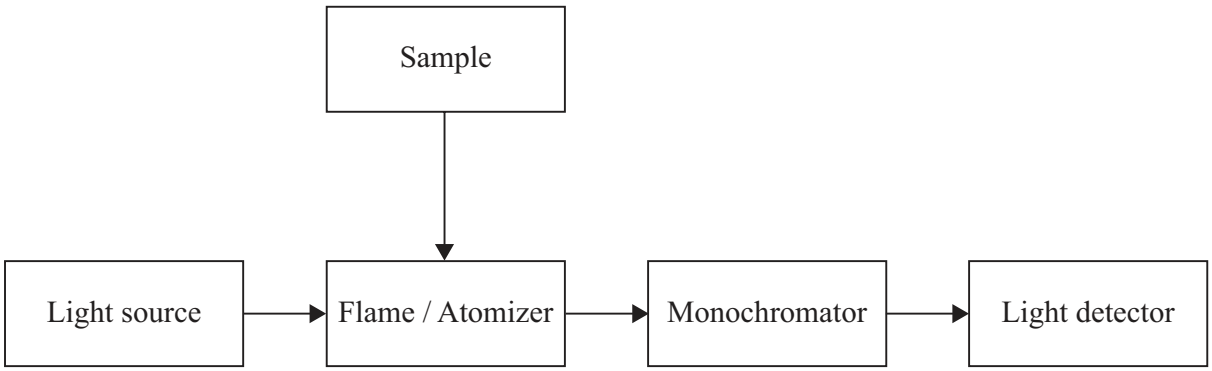
A2. A student analyses the amount of Cu^{2+} in a water sample using atomic absorption spectroscopy. A simplified diagram of the atomic absorption spectrophotometer is shown below.



(a) State the essential characteristic of the lamp providing the light source. *[1]*

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(b) Describe what happens to the Cu^{2+} (aq) ions when introduced into the atomizer. *[2]*

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(c) Describe the function of the monochromator. *[1]*

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(This question continues on the following page)

(Question A2 continued)

(d) Explain how the student can determine the concentration of $Cu^{2+}(aq)$ ions in the water sample using an atomic absorption spectrophotometer and a solution of 0.10 $mol\,dm^{-3}$ $CuSO_4$. *[4]*

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A3. Paper chromatography may be used to separate a mixture of sugars.

(a) State the stationary phase and an example of a mobile phase used in paper chromatography. *[2]*

Stationary phase:

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Mobile phase:

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(This question continues on the following page)

(Question A3 continued)

(b) The identity of two sugars in a mixture can be determined by measuring their R_f values, after staining.

(i) Describe how an R_f value can be calculated. *[1]*

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(ii) Calculate the R_f value for sugar 2 in the chromatogram below. *[1]*

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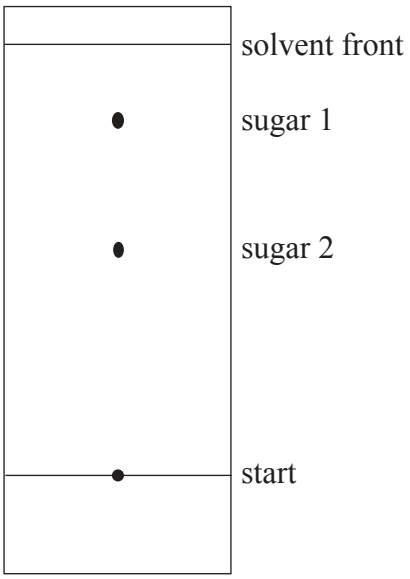

(c) Explain how the R_f value of sugar 2 could be used to identify it. *[2]*

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A4. (a) Explain why the nitrogen molecule, N_2, does not absorb infrared radiation. *[2]*

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(b) Describe **two** vibrations in the water molecule that absorb infrared radiation. *[2]*

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Option B — Human biochemistry

B1. The energy value of food may be determined using a food calorimeter.

The combustion of 2.00 g of dried bread in a food calorimeter raised the temperature of 600 cm^3 water from 20.5 °C to 29.0 °C. Calculate the energy content of bread in kJ per 100 g. Specific heat capacity of water = 4.18 J g^{-1} K^{-1}. *[4]*

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B2. Proteins are natural polymers.

(a) List **four** major functions of proteins in the human body. *[2]*

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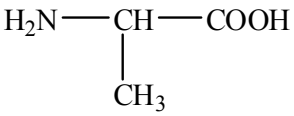
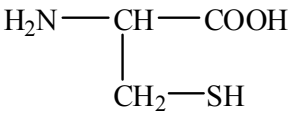
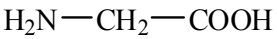
(This question continues on the following page)

(Question B2 continued)

(b) Deduce the structures of **two** different tripeptides that can be formed when all three amino acids given below react together. *[2]*







(c) Deduce the number of tripeptides that could be formed by using all three of the above amino acids to form a tripeptide. *[1]*

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(d) State the type of bonding that is responsible for the primary and secondary structures of proteins. *[2]*

Primary:

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Secondary:

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(This question continues on the following page)

(Question B2 continued)

(e) Describe and explain the tertiary structure of proteins. Include in your answer all the bonds and interactions responsible for the tertiary structure. *[2]*

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B3. (a) State what is meant by the term *dietary fibre*. *[1]*

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(b) Describe the importance of a high fibre diet and list **two** health problems related to a low fibre diet. *[2]*

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B4. Hormones play an important role in the body.

(a) Outline the function and production of hormones in the body. *[2]*

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(b) In many communities there are people who use steroids appropriately, and others who abuse them. Outline **one** appropriate use and **one** abuse of steroids. *[2]*

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Option C — Chemistry in industry and technology

C1. Nanotechnology creates and uses structures that have novel properties because of their size.

(a) State the size range of structures which are involved in nanotechnology. *[1]*

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(b) Distinguish between physical and chemical techniques in manipulating atoms to form molecules. *[2]*

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(c) Discuss **two** implications of nanotechnology. *[2]*

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C2. The blast furnace is used extensively for the production of iron.

(a) State the formula and name of **one** main ore used as a source of iron. *[1]*

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(b) Write an equation that would describe the following processes in the blast furnace.

(i) Reduction of the iron ore to produce the iron: *[1]*

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(ii) A reaction used to remove impurities from the iron: *[1]*

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C3. Addition polymers are extensively used in society. The properties of addition polymers may be modified by the introduction of certain substances.

(a) For two different addition polymers, describe and explain **one** way in which the properties of addition polymers may be modified. *[4]*

Polymer one:

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Polymer two:

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(b) Describe and explain how the extent of branching affects the properties of poly(ethene). *[3]*

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(c) Discuss **two** advantages and **two** disadvantages of using poly(ethene). *[2]*

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C4. Detergents are one example of lyotropic liquid crystals.

State **one** other example of a lyotropic liquid crystal and describe the difference between lyotropic and thermotropic liquid crystals. *[3]*

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Option D — Medicines and drugs

D1. State the differences between the structures of morphine and diamorphine (heroin). State the names of all functional groups in the molecule of morphine. *[3]*

Differences:

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Functional groups:

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D2. Bacterial and viral infections require different types of medication.

(a) Outline **two** differences between bacteria and viruses. *[2]*

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(b) Antiviral drugs are used for the treatment of HIV and other viral infections. Describe **two** ways in which antiviral drugs work. *[2]*

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(This question continues on the following page)

(Question D2 continued)

(c) Discuss why viral infections are generally harder to treat than bacterial infections. *[3]*

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D3. Mild analgesics such as aspirin, and strong analgesics such as opiates, differ not only in their potency but also in the ways they act on the central nervous system.

(a) Describe how mild and strong analgesics provide pain relief. *[2]*

Mild analgesics:

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Strong analgesics:

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(This question continues on the following page)

(Question D3 continued)

(b) Discuss **two** advantages and **two** disadvantages of using morphine and other opiates for pain relief. *[4]*

Advantages:

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Disadvantages:

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D4. Fluoxetine hydrochloride (Prozac®) is a common depressant. Depressants have many therapeutic uses.

(a) State **three** other common depressants. *[3]*

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(b) Describe **one** effect, other than relieving depression, of moderate doses of depressants on patients. *[1]*

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Option E — Environmental chemistry

E1. The greenhouse effect maintains the Earth's average temperature at a habitable level. The components of the Earth's atmosphere responsible for this effect are called greenhouse gases.

(a) Major greenhouse gases are water vapour and carbon dioxide. State **two** other greenhouse gases. *[2]*

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(b) Describe how greenhouse gases cause the greenhouse effect. *[3]*

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(c) Discuss **three** possible implications of global warming on world food production. *[3]*

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E2. Disposal of radioactive waste is a major ecological concern.

(a) State **one** source of low-level radioactive waste and **one** source of high-level radioactive waste. *[2]*

Low-level waste:

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High-level waste:

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(b) Consider the following types of radioactive waste.

Type	Waste	Isotopes	Half-life	Emissions
A	syringes and other disposable materials used in radiotherapy	^{90}Y	64 hours	β^-
B	diluted aqueous solution of cobalt-60 complexes	^{60}Co	5.3 years	β^-, γ
C	partially processed solid materials from a nuclear reactor	U, Pu, Am and other actinides	10^3–10^9 years	α, γ

Identify which method can be used for the disposal of radioactive wastes **A**, **B** and **C**.

(i) Vitrification followed by long-term underground storage: *[1]*

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(ii) Storage in a non-shielded container for two months followed by the disposal as normal (non-radioactive) waste: *[1]*

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(iii) Ion-exchange and adsorption on iron(II) hydroxide, storage in a shielded container for 50 years, then mixing with concrete and shallow land burial: *[1]*

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E3. The ozone layer protects living organisms from dangerous UV radiation. In the Earth's stratosphere, ozone is photochemically formed from oxygen by the following two-step process.

$$O_2 \xrightarrow{\text{UV light}} 2O\bullet$$
$$O_2 + O\bullet \longrightarrow O_3$$

(a) Ozone decomposition can proceed photochemically. Describe, using chemical equations, the two-step mechanism of photochemical decomposition of ozone in the Earth's stratosphere. *[2]*

Step 1:

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Step 2:

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(b) Ozone decomposition can also be catalysed by ozone-depleting substances such as chlorofluorocarbons, CFCs. State **two** alternatives to CFCs. *[1]*

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E4. Intensive farming changes the composition of soils and may lead to soil degradation. Common types of soil degradation include *salinization*, *nutrient depletion* and *soil pollution*.

Discuss **two** types of soil degradation. In your answer you should describe how each type of soil degradation occurs and suggest **one** negative effect on the environment. *[4]*

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Option F — Food chemistry

F1. The preservation of food is important around the world.

(a) Explain the meaning of the term *shelf life*. *[2]*

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(b) Discuss **two** factors that can affect the shelf life of food. *[4]*

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F2. (a) Describe the differences in the structure between the saturated fatty acid $C_{16}H_{32}O_2$ and the unsaturated fatty acid $C_{16}H_{26}O_2$. *[3]*

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(b) Describe how $C_{16}H_{26}O_2$ can be converted to $C_{16}H_{32}O_2$. *[3]*

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(c) Fatty acids are components of fats and oils.

(i) Describe **one** advantage of the products formed by hydrogenating fats and oils. *[1]*

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(ii) Describe **one** disadvantage of the products formed by hydrogenating fats and oils. *[1]*

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F3. (a) Define the term *antioxidant* and state its use. *[2]*

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(b) Discuss **one** disadvantage of using natural and synthetic antioxidants. *[2]*

Natural antioxidants:

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Synthetic antioxidants:

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F4. Flavanones are pigments that produce a red colouration. Distinguish between a pigment and a dye. *[2]*

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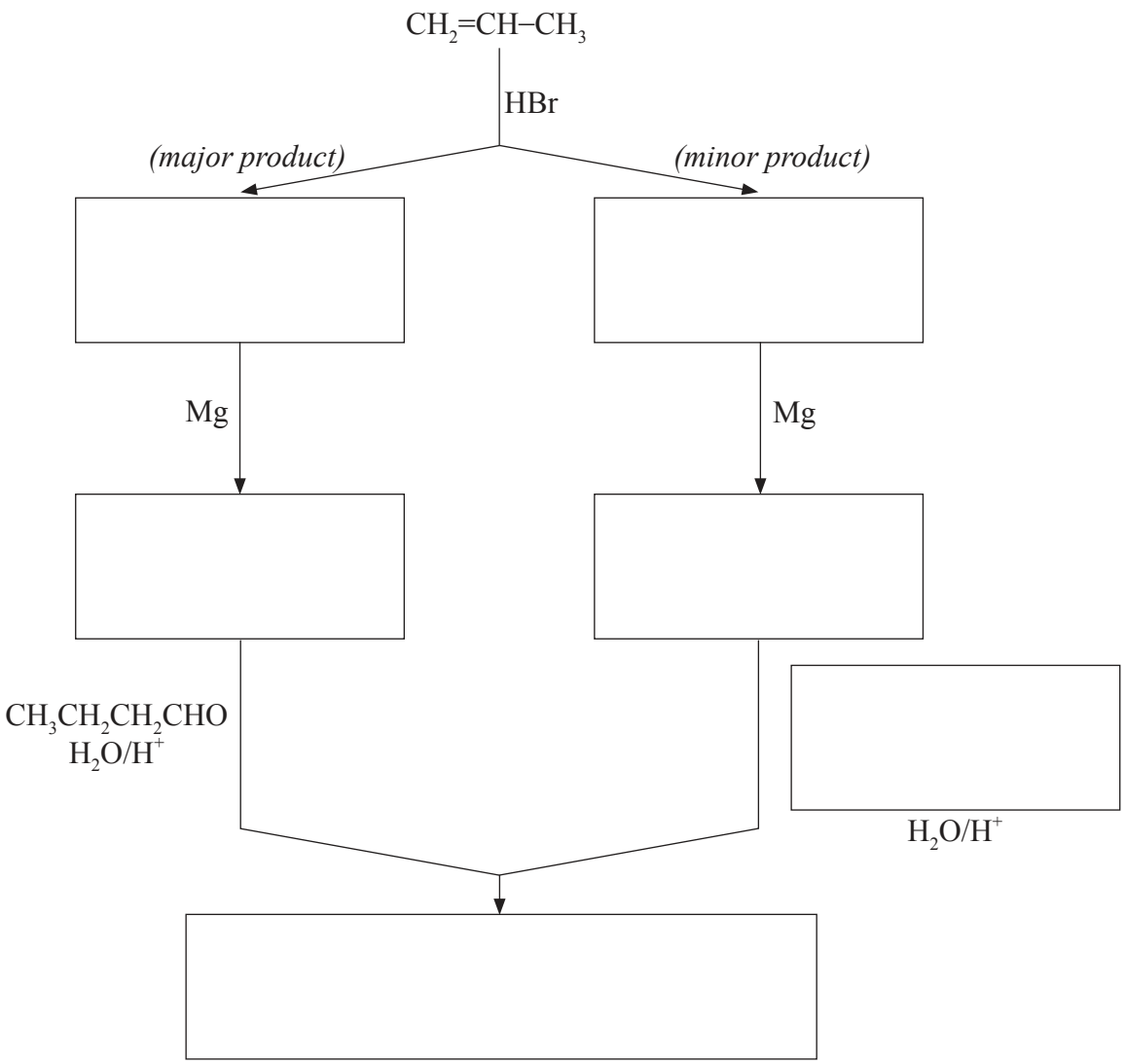
Option G — Further organic chemistry

G1. Addition of hydrogen halides to unsymmetrical alkenes produces a mixture of halogenoalkanes. The latter can be converted into Grignard reagents by reaction with magnesium metal and then used for the preparation of various organic molecules with an increased number of carbon atoms.

(a) State in the boxes below, the formulas of the organic substances needed to complete the following reaction pathways. *[4]*



(This question continues on the following page)

(Question G1 continued)

(b) Describe, using equations and curly arrows to represent the movement of electron pairs, the mechanism of the reaction between propene and hydrogen bromide. Compare the relative stabilities of the two intermediate carbocations which lead to the formation of the major and minor products. *[4]*

G2. Hydrolysis of aliphatic and aromatic halides occurs under different conditions.

State an equation, using structural formulas, to show the reaction of 1-chloro-2-(chloromethyl) benzene with excess sodium hydroxide at room temperature. *[2]*

G3. Deduce a **two-step** reaction pathway for the conversion of butan-1-ol into 1,2-dibromobutane. State the appropriate equations, the reaction conditions and the reaction type for each step. *[5]*

Step 1:

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Reaction type for step 1:

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Step 2:

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Reaction type for step 2:

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G4. The acidity of carboxylic acids depends on the carbon chain length and the nature of substituents in their molecules. Table 15 of the Data Booklet provides some examples.

(a) State and explain how the presence of halogen atoms in the hydrocarbon chain affects the acidity of carboxylic acids. *[3]*

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(b) State how the acidity of 3-chloropropanoic acid compares to that of propanoic acid and chloroethanoic acid. *[1]*

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(c) Suggest the pK_a value for 3-chloropropanoic acid. *[1]*

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