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CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

CHEMISTRY

UNIT 1 – PAPER 01

1 hour 45 minutes

Candidates are advised to use the first 15 minutes for reading through this paper carefully. Writing may begin during this time.

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of NINE questions.
2. There are THREE questions from each Module. Answer ALL questions.
3. Write answers in this booklet.
4. ALL working must be shown in this booklet.
5. The use of non-programmable calculators is permitted.
6. A data booklet is provided.

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MODULE 1

Answer ALL questions.

1. A sample of titanium gives the mass spectrum shown in Figure 1.

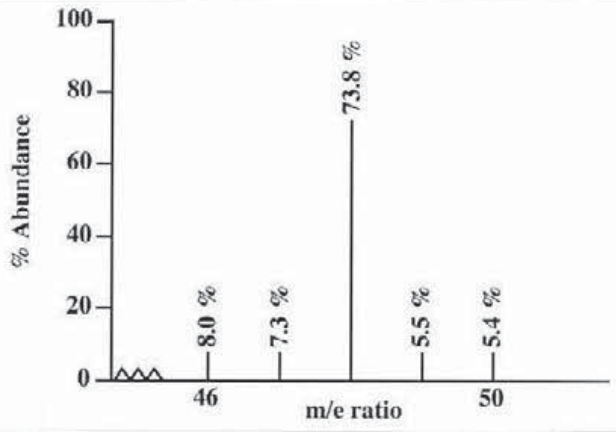


Figure 1

(a) Calculate the relative atomic mass A_r of titanium.

_____

_____

_____

[2 marks]

(b) Use the data booklet and the mass spectrum given above to determine the number of protons and neutrons of the most abundant isotope of titanium.

_____

_____

[3 marks]

(c) Using s, p, d, f notation, write the electronic configuration of titanium.

_____

[1 mark]

(d) Draw the shapes of the orbitals of principal quantum number n = 2 in the titanium atom.

[2 marks]

(e) Another isotope of titanium, ^{51}Ti, decays by β -emission. A β-particle has no mass and a single negative charge. Write an equation to represent the decay of a ^{51}Ti atom.

_____

[2 marks]

Total 10 marks

2. Table 1 below gives the bond angles in molecules of ammonia and water, and the boiling point of each of these substances.

TABLE 1: BOND ANGLE AND BOILING POINT OF AMMONIA AND WATER

	Bond angle	**Boiling point / °C**
Ammonia	107°	– 31
Water	104.5°	100

(a) Sketch the shape of BOTH the water and ammonia molecules.

[2 marks]

(b) Explain the difference in the

(i) bond angles of the ammonia and water molecules

_____

_____

_____

[3 marks]

GO ON TO THE NEXT PAGE

(ii) boiling points of water and ammonia.

[2 marks]

(c) (i) Suggest the shape of a molecule of hydrogen sulphide.

[1 mark]

(ii) How would the boiling point of hydrogen sulphide compare with that of ammonia? Explain your answer.

[2 marks]

Total 10 marks

3. (a) Define the term 'enthalpy change of solution'.

[1 mark]

(b) (i) State Hess' Law.

[1 mark]

(ii) Use the data in Table 2 and apply Hess' Law to determine the enthalpy of solution of hydrogen fluoride gas.

TABLE 2: ENTHALPY CHANGES ASSOCIATED WITH DISSOLUTION OF HF GAS

Enthalpy change (Δ H)	**KJ mol^{-1}**
Δ H HF Bond dissociation (BD)	+ 562
Δ H F Electron Affinity (EA)	– 328
Δ H H Ionization Energy (I.E)	+ 1310
Δ H F^- Hydration (Hyd)	– 506
Δ H H^+ Hydration (Hyd)	– 1300

[5 marks]

(iii) Any chemical change involves processes of bond making and bond breaking. Classify EACH process as exothermic or endothermic and, hence, explain the value obtained in (b) (ii) on page 5.

[3 marks]

Total 10 marks

MODULE 2

Answer ALL questions.

4. Aspartame, the structure shown in Figure 2 below, is an artificial sweetener. It is about 200 times sweeter than sucrose.

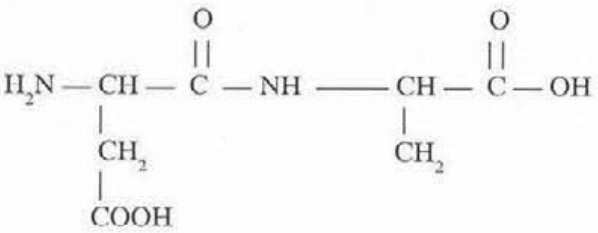


Figure 2

(a) Which of the functional groups present in aspartame would react with

(i) ethanol?

[1 mark]

(ii) dilute hydrochloric acid?

[2 marks]

(iii) ethanoyl chloride?

_____

[1 mark]

(b) Name the OTHER chemical that is required for the reaction with ethanol to occur.

_____

[1 mark]

(c) The scheme in Figure 3 shows that the conversion of **A** to **C** occurs in two steps. **A** is converted to **B** on treatment with $SOCl_2$.

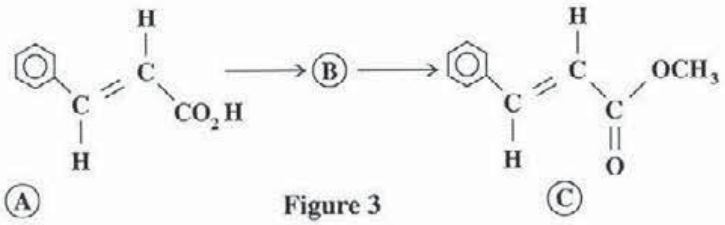


Figure 3

(i) Draw the structural formula of B.

[1 mark]

(ii) State the reagents and conditions required for the conversion of **B** to **C**.

_____

[2 marks]

(iii) State ONE physical property that is characteristic of BOTH Compound **C** and that obtained in the reaction described in (b) above. Explain your answer.

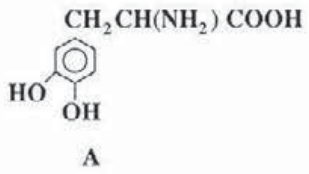
_____

_____

[2 marks]

Total 10 marks

5. Dopa is a naturally occurring amino acid, used in the treatment of Parkinson's disease. A condensed formula, A, of this molecule is shown in Figure 4.



A

Figure 4

(a) State TWO reasons why carbon can form straight chains and rings.

_____

_____

[2 marks]

(b) Write the molecular formula of Dopa.

_____

[1 mark]

(c) Dopa is one isomeric form of the molecular formula in (b) above.

(i) Define the term 'isomerism'.

_____

_____

[1 mark]

(ii) State TWO types of isomerism which can be exhibited by a molecule with formula A.

Type I : _____

Type II: _____

[2 marks]

(iii) Draw the full structural formulae of TWO isomers for each type of isomerism stated in (c) (ii) on page 8.

Type I:

Type II:

[4 marks]

Total 10 marks

6. The sequence of monomer units in a macromolecule is called its primary structure. Part of the primary structure of one macromolecule, **A**, is shown in Figure 5.

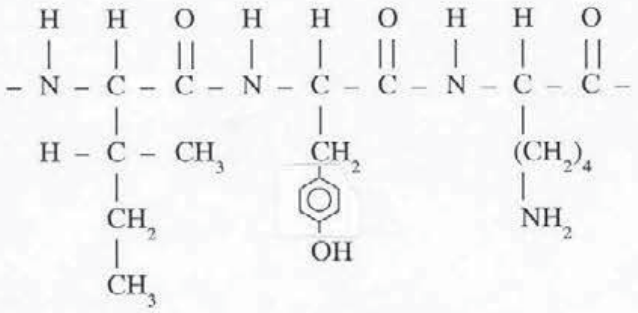


Figure 5

(a) (i) How many monomer units are present in this portion of the macromolecule?

_____

[1 mark]

(ii) Draw the displayed structure of two monomers used to make **A**.

[2 marks]

(b) To what class of compounds do the monomers and macromolecule, **A**, belong?

Monomer:

_____

Macromolecule **A**:

_____

[2 marks]

(c) Nylon 6.6 has similar characteristics to **A**.

(i) Name the type of reaction that occurs when nylon 6.6 or **A** is boiled with concentrated hydrochloric acid.

_____

[1 mark]

(ii) Copy the structure of **A** and use it to illustrate the changes that occur during the reaction described in (c) (i) above.

[1 mark]

(iii) Draw the fully displayed structure of ONE product of the reaction described in (c) (i) above.

[1 mark]

(d) State ONE common structural feature and ONE different structural feature in nylon 6.6 and **A**.

_____

_____

[2 marks]

Total 10 marks

MODULE 3

Answer ALL questions.

7. In order to estimate the % of Fe^{2+} in a compound M, a solution of M is titrated against a standard solution of potassium permanganate (manganate (VII)). The permanganate is standardised by titration against the primary standard, ethanedioic acid.

(a) State THREE characteristics of ethanedioic acid that make it a suitable primary standard.

_____

_____

_____

[3 marks]

(b) In preparing the solution of ethanedioic for titration against the permanganate, two pieces of laboratory equipment with a high degree of accuracy are required. Name these TWO pieces of equipment.

_____

_____

[2 marks]

(c) 25.0 cm^3 of the aqueous solution of M requires 24.80 cm^3 of 0.02 mol dm^{-3} permanganate for complete reaction. The equation for the reaction is

$$5\ Fe^{2+}(aq) + MnO_4^-(aq) + 8H^+(aq) \rightarrow 5\ Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O$$

Calculate EACH of the following:

(i) The number of moles MnO_4^- used

[1 mark]

(ii) The number of moles Fe^{2+} in the 25.0 cm^3 of aqueous M

[1 mark]

GO ON TO THE NEXT PAGE

(iii) The number of moles Fe^{2+} in 1.0 dm^3 of M (aq)

[1 mark]

(iv) The mass of Fe^{2+} in 1 dm^3 of M (aq)

[1 mark]

(v) The % Fe^{2+} in the compound [The mass concentration of M is 40.90 g dm^{-3}.]

[1 mark]

Total 10 marks

8. A variety of chromatographic methods can be used to separate mixtures.

(a) (i) What is meant by retention time as applied to gas liquid chromatography (GLC)?

_____

_____

[1 mark]

(ii) Distinguish between a stationary phase and a mobile phase used in chromatography.

_____

_____

_____

_____

[2 marks]

(iii) Give ONE example EACH of commonly used stationary and mobile phases in GLC.

_____

_____

[2 marks]

(b) Samples of TWO different brands of black ink are separated into their constituent parts using paper chromatography. Both samples contain a red dye. In the first sample the solvent travels 7.54 cm, while the red dye travels 4.67 cm. In the second sample the red dye travels 3.31 cm while the solvent travels 5.34 cm.

(i) Calculate the R_f values for the TWO samples.

[2 marks]

(ii) Deduce whether the same red dye is used to make both types of ink. Give TWO reasons for your answer.

[3 marks]

Total 10 marks

9. (a) Infra red (IR) spectroscopy is widely used to determine the structure of molecules. State the principles upon which infra red (IR) spectroscopy is based.

[3 marks]

(b) Even though air consists of 78% N_2 and 21% O_2, these gases do not contribute to global warming. Explain this phenomenon.

[2 marks]

(c) Explain how the IR spectra may be used to distinguish between functional groups in organic compounds.

_____

_____

[1 mark]

(d) The carbonyl group, $>C=O$, has absorption peaks in the region of 1680 to 1750 cm^{-1}, while the peaks for the alkene group, $>C=C<$, are manifested in the region of 1610 to 1680 cm^{-1}. What does this say about the bond energies of the $>C=O$ and $>C=C<$ functional groups?

_____

_____

[1 mark]

(e) Suggest ONE reason why HCl has only one peak in its IR spectrum.

_____

_____

[1 mark]

(f) (i) The monochromator and sample cell are components of the IR spectrophotometer. Give ONE reason why the monochromator and sample cell are not constructed of glass or quartz.

_____

_____

[1 mark]

(ii) What material may be used instead of quartz or glass?

_____

_____

[1 mark]

Total 10 marks

END OF TEST