1 Carbon occurs in a wide range of compounds and is essential to living systems.

(a) Two isotopes of carbon are ^{12}C and ^{13}C.

(i) State what is meant by the term *isotopes*.

....

.... **[1]**

(ii) Isotopes of carbon have the same chemical properties.

Explain why.

....

.... **[1]**

(iii) The ^{12}C isotope is used as the standard measurement of relative masses.

Define the term *relative isotopic mass*.

....

....

....

.... **[2]**

(b) One form of naturally occurring carbon is graphite.

The table below lists some properties of graphite.

electrical conductivity	good conductor
hardness	soft
melting point	very high

- Describe the bonding and structure in graphite.

- Explain, in terms of bonding and structure, the properties of graphite shown above.

In your answer, you should use appropriate technical terms, spelt correctly.

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.... **[5]**

(c) In the sixteenth century, a large deposit of graphite was discovered in the Lake District.

People at the time thought that the graphite was a form of lead.

Nowadays, graphite is used in pencils but it is still referred to as 'pencil lead'.

A student decided to investigate the number of carbon atoms in a 'pencil lead'. He found that the mass of the 'pencil lead' was 0.321 g.

(i) Calculate the amount, in mol, of carbon atoms in the student's pencil lead.

Assume that the 'pencil lead' is pure graphite.

answer = ... mol **[1]**

(ii) Using the Avogadro constant, N_A, calculate the number of carbon atoms in the student's 'pencil lead'.

number of carbon atoms = ... **[1]**

[Total: 11]

2 A student used the internet to research chlorine and some of its compounds.

(a) He discovered that sea water contains chloride ions. The student added aqueous silver nitrate to a sample of sea water.

(i) What would the student see?

.... **[1]**

(ii) Write an ionic equation, including state symbols, for the reaction that would occur.

.... **[2]**

(iii) After carrying out the test in **(i)**, the student added dilute aqueous ammonia to the mixture.

What would the student see?

.... **[1]**

(b) The student also discovered that chlorine, Cl_2, is used in the large-scale treatment of water.
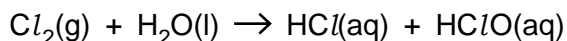
(i) State **one** benefit of adding chlorine to water.

....

.... **[1]**

(ii) Not everyone agrees that chlorine should be added to drinking water.

Suggest **one** possible hazard of adding chlorine to drinking water.

....

.... **[1]**

(c) The equation for the reaction of chlorine with water is shown below.

$$Cl_2(g) \ + \ H_2O(l) \ \rightarrow \ HCl(aq) \ + \ HClO(aq)$$

(i) State the oxidation number of chlorine in:

Cl_2 ………………… HCl ………………… HClO …………………   **[1]**

(ii) The reaction of chlorine with water is a *disproportionation* reaction.

Use the oxidation numbers in **(i)** to explain why.

....

....

....

.... **[2]**

(iii) Chlorine reacts with sodium hydroxide to form bleach in another disproportionation reaction.

Write an equation for this reaction.

.... **[1]**

(d) Two other chlorine compounds of chlorine are chlorine dioxide and chloric(V) acid.

(i) Chlorine dioxide, ClO_2, is used as a bleaching agent in both the paper and the flour industry. When dry, ClO_2 decomposes explosively to form oxygen and chlorine.

Construct an equation for the decomposition of ClO_2.

.... **[1]**

(ii) Chloric(V) acid has the following percentage composition by mass:

H, 1.20%; Cl, 42.0%; O, 56.8%.

Using this information, calculate the empirical formula of chloric(V) acid.

Show **all** of your working.

empirical formula = ... **[2]**

(iii) What does (V) represent in chloric(V) acid?

....

.... **[1]**

[Total: 14]

3 Periodicity is a repeating pattern across different periods.

(a) First ionisation energy shows a trend across Period 2.

The first ionisation energies of lithium, carbon and fluorine are shown in **Table 5.1** below.

Element	Lithium	Carbon	Fluorine
First ionisation energy / kJ mol^{-1}	520	1086	1681

Table 5.1

(i) Explain the trend across Period 2 shown in **Table 5.1**.

In your answer, you should use appropriate technical terms, spelled correctly.

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.... **[3]**

(ii) Solid carbon exists in two forms, diamond and graphite.

Explain why it is unnecessary to refer to carbon as either diamond or graphite in **Table 5.1**.

....

.... **[1]**

These differences in melting points are the result of different types of structure and different forces or bonds between the particles in the structures.

Part of the table below has been filled in.

Complete the table below.

	Lithium	Carbon (diamond)	Fluorine
Melting point/°C	181	3550	−220
Structure	Giant		Simple
Force or bond overcome on melting	Metallic bond		
Particles between which the force or bond is acting			

[6]

[Total: 10]