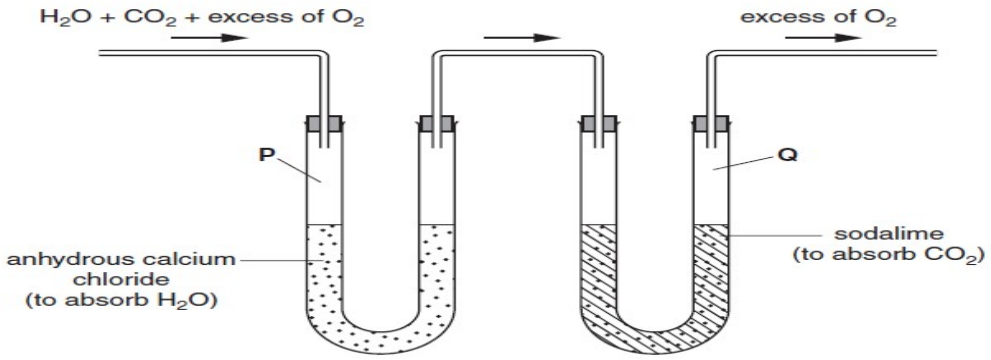
SECTION A

1 *Use of the Data Booklet is relevant to this question.*
Analytical chemists can detect very small amounts of amino acids, down to 3×10^{-21} mol.
How many molecules of an amino acid (*M*r = 200) would this be?
A 9 **B** 200 **C** 1800 **D** 360 000

2 *Use of the Data Booklet is relevant to this question.*
A garden fertiliser is said to have a phosphorus content of 30.0% 'P_2O_5 soluble in water'.
What is the percentage by mass of phosphorus in the fertiliser?
A 6.55% **B** 13.1 % **C** 26.2% **D** 30.0%

3 A sample of the hydrocarbon C_6H_{12} is completely burned in dry oxygen and the product gases arecollected as shown.
[*A*r : H, 1 ; C, 12 ; O, 16.]



The increases in mass of the collecting vessels **P** and **Q** of the apparatus are *M*P and *M*Q,respectively.
What is the ratio *M*P / *M*Q?
A 0.41 **B** 0.82 **C** 1.2 **D** 2.4

4 Unnilpentium is an artificial element. One of its isotopes is $^{262}_{105}$Unp.

Which of the following statements is correct?
A $^{262}_{105}$Unp has a nucleon number of 105.
B The atom $^{260}_{105}$X is an isotope of $^{262}_{105}$Unp.
C There are 262 neutrons in $^{262}_{105}$Unp.
D The proton number of $^{262}_{105}$Unp is 262.

5 The table gives the successive ionisation energies for an element *X*.

	1st	2nd	3rd	4th	5th	6th
ionisation energy / kJ mol^{-1}	950	1800	2700	4800	6000	12300

What could be the formula of the chloride of *X*?
A XCl **B** XCl_2 **C** XCl_3 **D** XCl_4

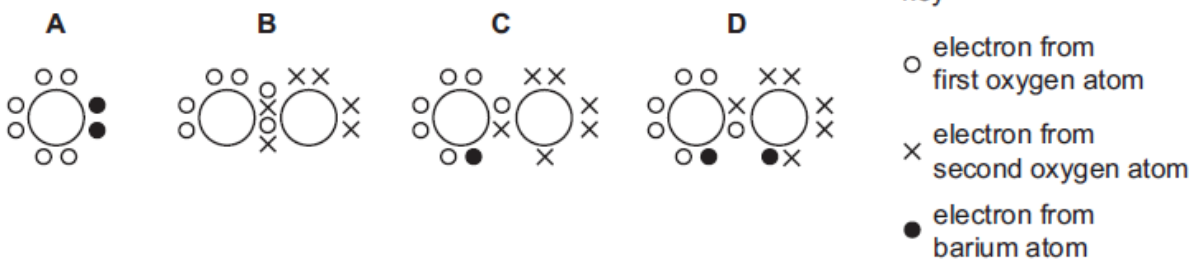
6 Which molecule contains only six bonding electrons?
A C_2H_4 **B** C_2F_6 **C** H_2O **D** NF_3

7 Which ion has more electrons than protons and more protons than neutrons?
[H = $^{1}_{1}$H ; D = $^{2}_{1}$ H ; O = $^{16}_{8}$ O]
A D^- **B** H_3O^+ **C** OD^- **D** OH^-

8 What is the electronic configuration of an element with a second ionisation energy higher thanthat of each of its neighbours in the Periodic Table?
A $1s^2 2s^2 2p^6 3s^2$
B $1s^2 2s^2 2p^6 3s^2 3p^1$
C $1s^2 2s^2 2p^6 3s^2 3p^2$
D $1s^2 2s^2 2p^6 3s^2 3p^3$

9 Which compound has a boiling point that is influenced by hydrogen bonding?
A CH_3CHO
B CH_3OCH_3
C HCO_2H
D HCO_2CH_3

10 When barium metal burns in oxygen, the ionic compound barium peroxide, BaO_2, is formed.Which dot-and-cross diagram represents the electronic structure of the peroxide anion in BaO_2?



SECTION B

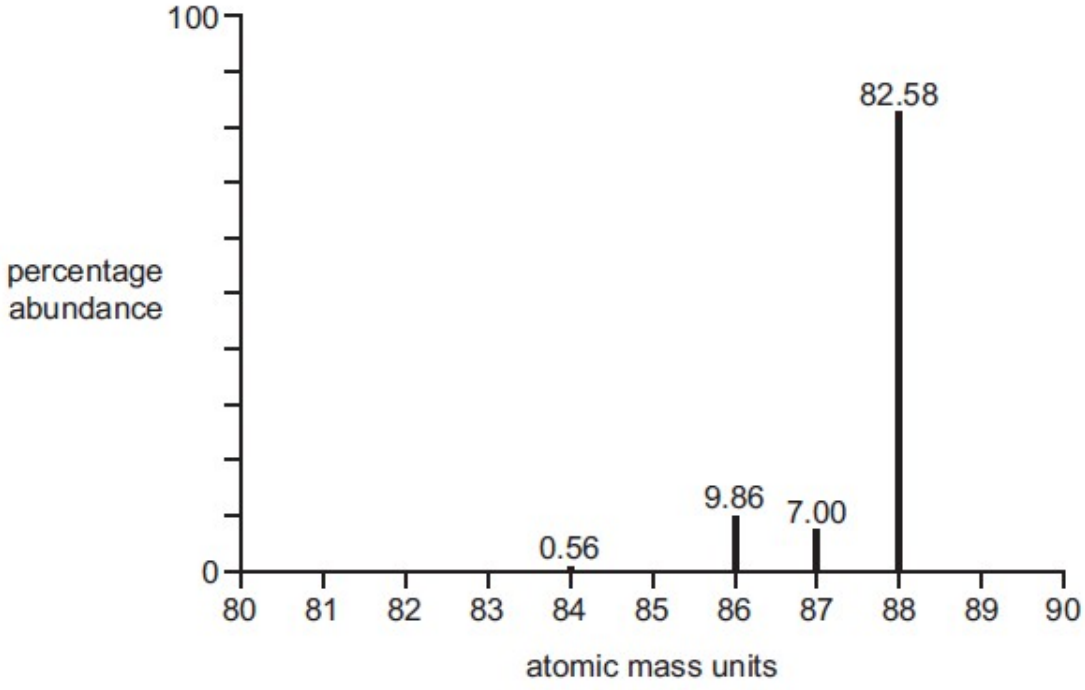
1 **(a)** Successive ionisation energies for the elements magnesium to barium are given in the table.

element	1st ionisation energy / kJ mol^{-1}	2nd ionisation energy / kJ mol^{-1}	3rd ionisation energy / kJ mol^{-1}
Mg	736	1450	7740
Ca	590	1150	4940
Sr	548	1060	4120
Ba	502	966	3390

(i) Explain why the first ionisation energies decrease down the group. [3]

(ii) Explain why, for each element, there is a large increase between the 2nd and 3rd ionization energies. [2]

(b) A sample of strontium, atomic number 38, gave the mass spectrum shown. The percentageabundances are given above each peak.



(i) Complete the full electronic configuration of strontium. [1]

(ii) Explain why there are four different peaks in the mass spectrum of strontium. [1]

(iii) Calculate the atomic mass, *A*r, of this sample of strontium.
Give your answer to **three** significant figures. [2]

(c) Group VII is the only group in the Periodic Table containing elements in all three states of matter at room conditions.
State and explain, in terms of intermolecular forces, the trend in the boiling points of theelements down Group VII. [4]

(d) Compounds containing different halogen atoms covalently bonded together are called interhalogen compounds.

(i) One interhalogen compound can be prepared by the reaction between iodine and fluorine.
This compound has *M*r = 222 and the percentage composition by mass: F, 42.8; I, 57.2.
Calculate the molecular formula of this interhalogen compound. [3]

(ii) Another interhalogen compound has the formula IC*l*.
Draw a 'dot-and-cross' diagram of a molecule of this compound, showing outer shellelectrons only. Explain whether or not you would expect this molecule to be polar. [2]

[Total: 18]

2 Valence Shell Electron Pair Repulsion theory (VSEPR) is a model of electron-pair repulsion(including lone pairs) that can be used to deduce the shapes of, and bond angles in, simplemolecules.

(a) Complete the table below by using simple hydrogen-containing compounds. Oneexample has been included.

number of bond pairs	number of lone pairs	shape of molecule	formula of a molecule with this shape
3	0	trigonal planar	BH_3
4	0		
3	1		
2	2		

[3]

(b) Tellurium, Te, proton number 52, is used in photovoltaic cells.
When fluorine gas is passed over tellurium at 150 °C, the colourless gas TeF_6 is formed.

(i) Draw a 'dot-and-cross' diagram of the TeF_6 molecule, showing outer electrons only.

(ii) What will be the shape of the TeF_6 molecule?

(iii) What is the F–Te–F bond angle in TeF_6? [4]

[Total: 7]

3 This question is about the bonding of covalent compounds.

(a) On the axes below, sketch the shapes of a 1s, a 2s, and a 2px orbital. [3]

(b) Covalent bonding occurs when two atoms share a pair of electrons.

Covalent bondingmay also be described in terms of orbital overlap with the formation of sigma bonds.

(i) How are the two atoms in a covalent bond held together? In your

answer, state whichparticles are attracted to one another and the nature of the force of attraction.

(ii) Draw sketches to show orbital overlap that produces the sigma bonding in the H_2 **and** HC*l* molecules. [4]

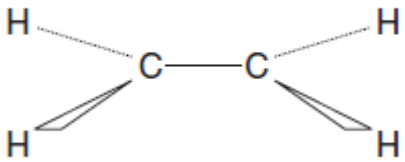
(c) The bond in the HC*l* molecule is said to be 'polar'.

(i) What is meant by the term *bond polarity*?

(ii) Explain why the HC*l* molecule is polar. [2]

(d) The bonding in ethene may be described as a mixture of sigma and pie bonding.

Each carbon atom in ethene forms three sigma bonds as shown below.



Copy the diagram and sketch the pie bond that is also present in

ethene. [1]

[Total : 10]

4 In 1814, Sir Humphrey Davy and Michael Faraday collected samples of a flammable gas, **A** ,from the ground near Florence in Italy.

They analysed **A** which they found to be a hydrocarbon. Further experiments were then carried out to determine the molecular formula of **A**.

(a) What is meant by the term *molecular formula*? [2]

Davy and Faraday deduced the formula of **A** by exploding it with an excess of oxygen and analysing the products of combustion.

(b) Complete and balance the following equation for the complete combustion of a hydrocarbon with the formula C*x*H*y*.

$$C_xH_y + \left(x + \frac{y}{4}\right)O_2 \rightarrow \text{.....} + \text{.....}$$

[2]

(c) When 10 cm^3 of **A** was mixed at room temperature with 50 cm^3 of oxygen (an excess)and exploded, 40 cm^3 of gas remained after cooling the

apparatus to room temperatureand pressure.
When this 40 cm^3 of gas was shaken with an excess of aqueous potassium hydroxide,KOH, 30 cm^3 of gas still remained.

(i) What is the identity of the 30 cm^3 of gas that remained at the end of the experiment?
(ii) The combustion of **A** produced a gas that reacted with the KOH(aq). What is the identity of this gas?
(iii) What volume of the gas you have identified in **(ii)** was produced by the combustionof **A**?
(iv) What volume of oxygen was used up in the combustion of **A**? [4]

(d) Use your equation in **(b)** and your results from **(c)(iii)** and **(c)(iv)** to calculate themolecular formula of **A**.
Show all of your working. [3]

[Total: 11]