IGCSE · Cambridge (CIE) · Chemistry

2 hours 15 questions

Theory Questions

Simple Molecules & Covalent Bonds

Covalent Bonds / Molecules & Compounds / Properties of Simple Molecular Compounds

Easy (5 questions)	/28
Medium (5 questions)	/36
Hard (5 questions)	/53
Total Marks	**/117**

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Easy Questions

1 (a) Extended Only

The table gives the melting points, the boiling points and the electrical properties of six substances A to F.

substance	melting point / °C	boiling point / °C	electrical conductivity as a solid	electrical conductivity as a liquid
A	-210	-196	does not conduct	does not conduct
B	777	1627	does not conduct	good conductor
C	962	2212	good conductor	good conductor
D	-94	63	does not conduct	does not conduct
E	1410	2355	does not conduct	does not conduct
F	1064	2807	good conductor	good conductor

Which **two** substances could be metals?

.....

(1 mark)

(b) Which substance could be nitrogen?

.....

(1 mark)

(c) Which substance could be an ionic compound?

.....

(1 mark)

(d) Which substance is a liquid at room temperature?

.....

(1 mark)

(e) Which substance could have a giant covalent structure similar to diamond?

.....

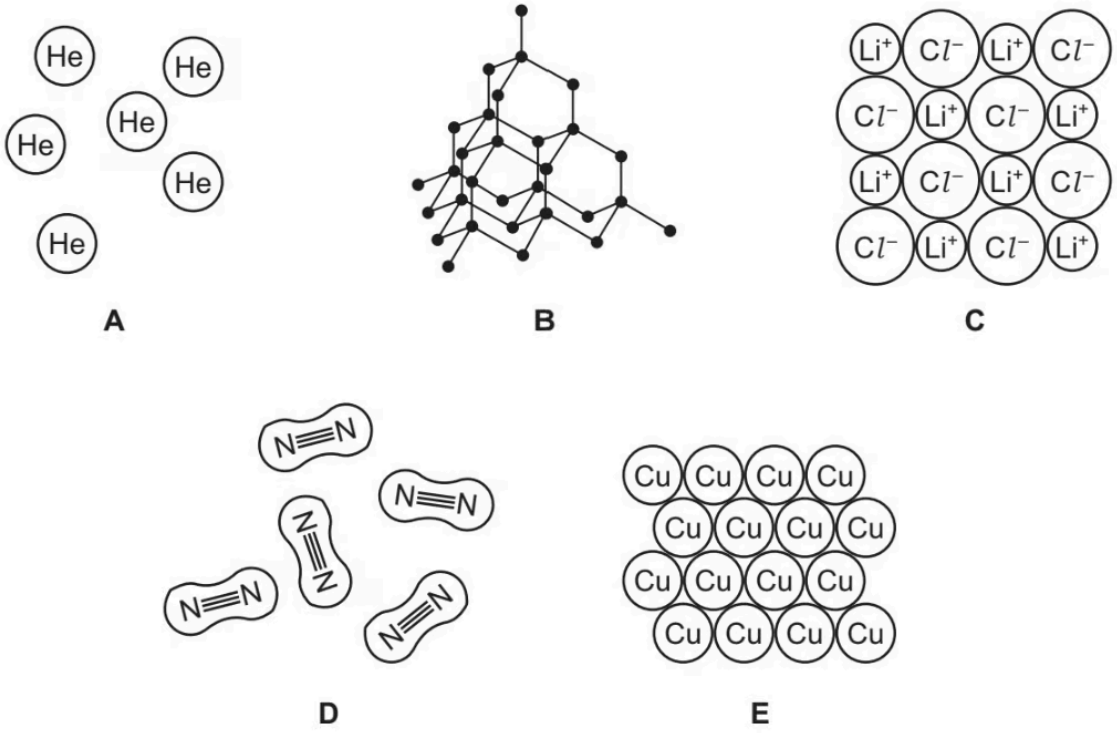
(1 mark)

(f) Which **two** substances could exist as simple covalent molecules?

.....

(1 mark)

2 (a) The diagrams show part of the structures of five substances, **A**, **B**, **C**, **D** and **E**.



Answer the following question about these structures. Each structure may be used once, more than once or not at all.

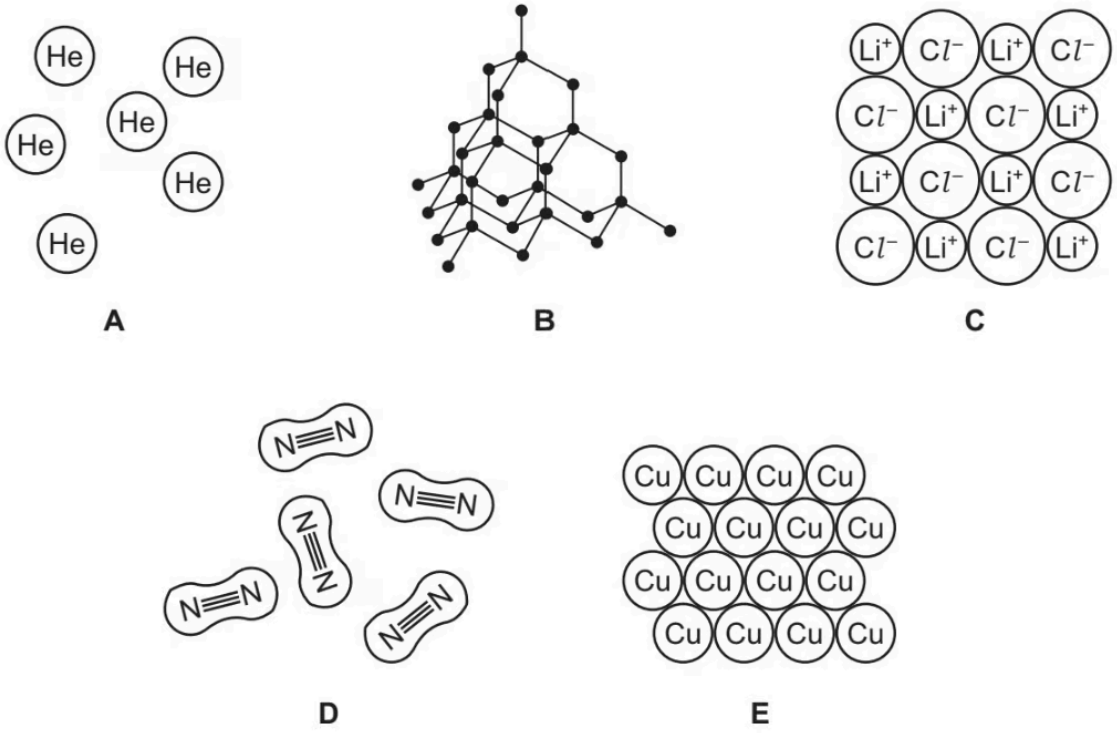
Which two of these structures, **A**, **B, C**, **D** or **E**, are covalently bonded?

.....

.....

(2 marks)

(b) The diagrams show part of the structures of five substances, **A, B**, **C**, **D** and **E**.



Answer the following question about these structures. Each structure may be used once, more than once or not at all.

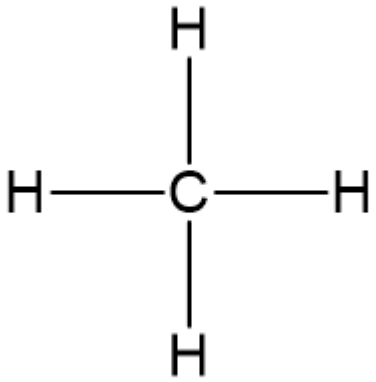
Which one of these structures, **A**, **B**, **C**, **D** or **E**, is a diatomic molecule?

.....

(1 mark)

3 (a) This question is about the structure and bonding in methane.

A molecule of methane is shown below.



Give the formula of this methane molecule.

.....

(1 mark)

(b) What type of bonding is found in methane?

Draw a circle around the correct answer.

ionic	covalent	metallic

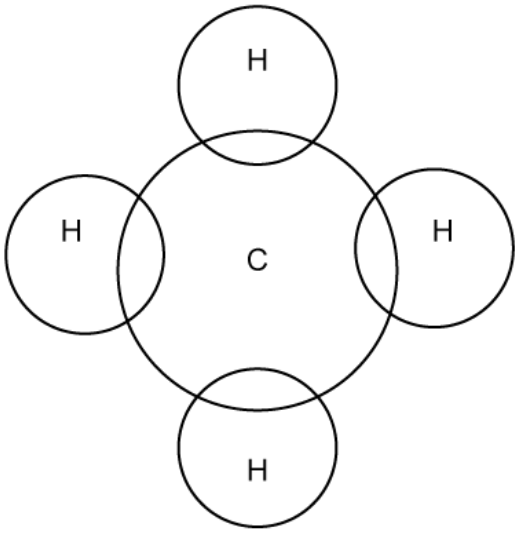
.....

(1 mark)

(c) The bonding in methane can be shown using a dot and cross diagram.

Carbon has four electrons in its outer shell, and hydrogen has one.

Complete the dot and cross diagram for methane.



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(2 marks)

(d) Methane is a gas at room temperature.

Which **one** of the following temperature values could be the boiling point of methane?

Draw a circle around the correct answer.

312 °C	**-162 °C**	**162 °C**	**897 °C**

.....

(1 mark)

4 (a) This question is about bonding and structure in different substances.

The list shows different substances.

carbon dioxide

calcium carbonate

copper

water

magnesium oxide

Which **one** of these substances has a simple molecular structure?

.....

(1 mark)

(b) Extended Only

Which **two** substances from part a) have intermolecular forces between particles?

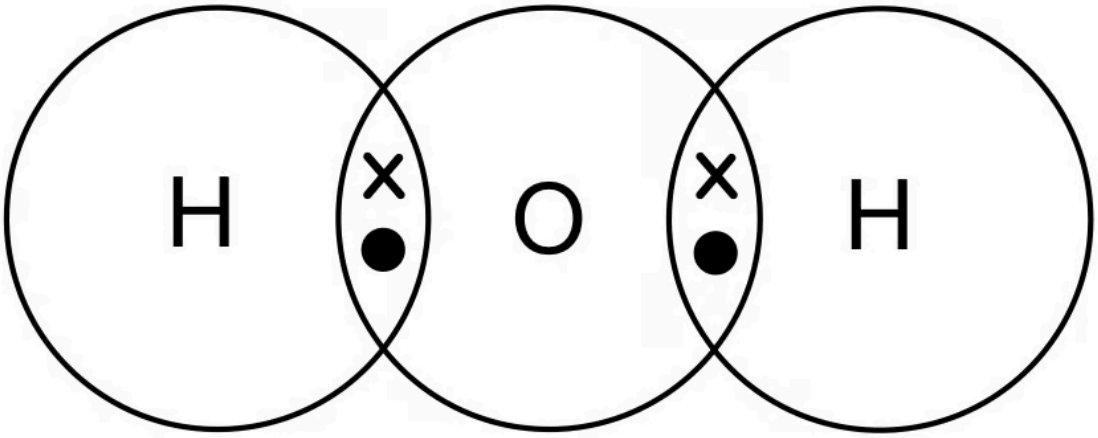
.....

.....

(2 marks)

(c) Complete the dot and cross diagram to show how electrons are shared in water.

Some of them have been done for you.



(1 mark)

(d) Extended Only

When a simple molecular substance melts, what is broken, the intermolecular forces or the bonds between atoms?

(1 mark)

5 (a) Ammonia gas, NH_3, has a simple molecular structure containing covalent bonds.

State how a covalent bond is formed between two atoms.

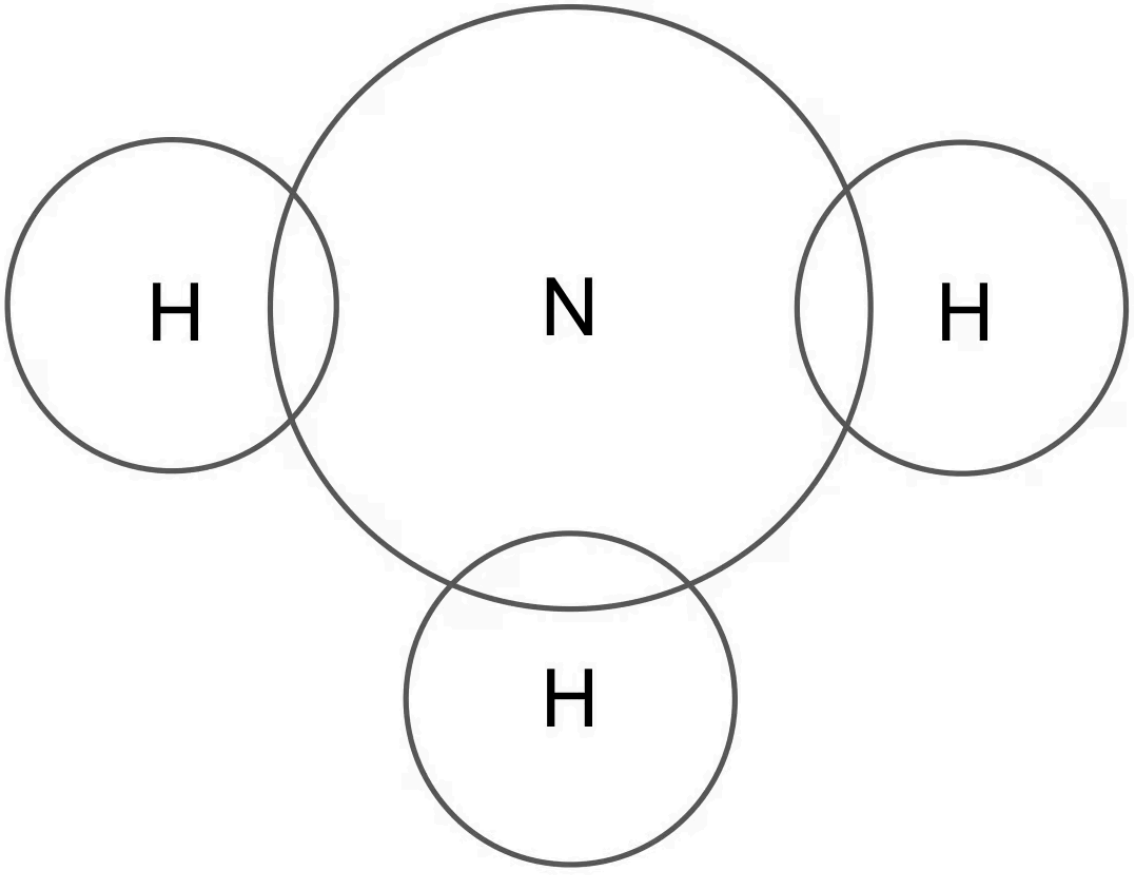
.....

.....

(2 marks)

(b) Complete the diagram below to show the bonding arrangement in a molecule of ammonia.

Show the outer shell electrons only.



.....

.....

(2 marks)

(c) Extended Only

Ammonia is a gas at room temperature.

Complete the sentences about ammonia using words from the list.

molecules	**covalent**	**weak**	**electrons**	**metallic**
intermolecular	**atoms**	**ions**	**ionic**	**strong**

Ammonia is a simple molecule that has strong ..... bonds between atoms and ..... intermolecular forces between molecules.

Only a small amount of energy is needed to overcome the forces between the ..... so ammonia has a low boiling point.

.....

.....

.....

(3 marks)

(d) Extended Only

Ammonia does not conduct electricity. Which **two** of these statements explains why ammonia does not conduct electricity? Tick **two** boxes.

It does not contain any free ions	
Its ions are in a fixed position	
It does not contain any free electrons	
It has delocalised electrons	

.....

.....

(2 marks)

Medium Questions

1 (a) The table below includes information about some of the elements in Period 2.

Element	Carbon	Nitrogen	Fluorine	Neon
Symbol	C	N	F	Ne
Structure	macromolecular	simple molecules N_2	simple molecules F_2	single atoms Ne
Boiling point / °C	4200	-196	-188	-246

Why does neon exist as single atoms but fluorine exists as molecules?

.....

.....

(2 marks)

(b) What determines the order of the elements in a period?

.....

(1 mark)

(c) Extended Only

When liquid nitrogen boils the following change occurs.

$$N_2\,(l) \rightarrow N_2\,(g)$$

The boiling point of nitrogen is very low even though the bond between the atoms in a nitrogen molecule is very strong. Suggest an explanation.

(2 marks)

(d) Draw a diagram showing the arrangement of the outer shell electrons in a molecule of nitrogen.

(2 marks)

2 (a) Strontium and sulfur chlorides both have a formula of the type XCl_2 but they have different properties.

Property	Strontium chloride	Sulfur chloride
Appearance	white crystalline solid	red liquid
Melting point / ^oC	87	-8
Particles present	ions	molecules
Electrical conductivity of solid	poor	poor
Electrical conductivity of liquid	good	poor

The formulae of the chlorides are similar because both elements have a valency of 2.

Explain why Group II and Group VI elements both have a valency of 2.

.....

.....

(2 marks)

(b) Draw a diagram showing the arrangement of the outer electrons in one covalent molecule of sulfur chloride. Use x to represent an electron from a sulfur atom. Use o to represent an electron from a chlorine atom.

.....

.....

.....

(3 marks)

(c) Explain the difference in electrical conductivity between the following.

i) Solid and liquid strontium chloride

[1]

ii) Liquid strontium chloride and liquid sulfur chloride

[1]

.....

.....

(2 marks)

3 (a) **Table 1.1** shows the properties of four substances.

Table 1.1

substance	boiling point	electrical conductivity of solid	electrical conductivity when molten	density in g/cm^3
aluminium	high	conducts	conducts	2.70
diamond				3.51
potassium bromide	high	does not conduct	conducts	2.75
sulfur	low	does not conduct		2.07

Complete **Table 1.1** to show the electrical conductivity of solid diamond and molten sulfur.

.....

.....

(2 marks)

(b) State one piece of evidence from the table that shows that sulfur is a simple molecular substance.

.....

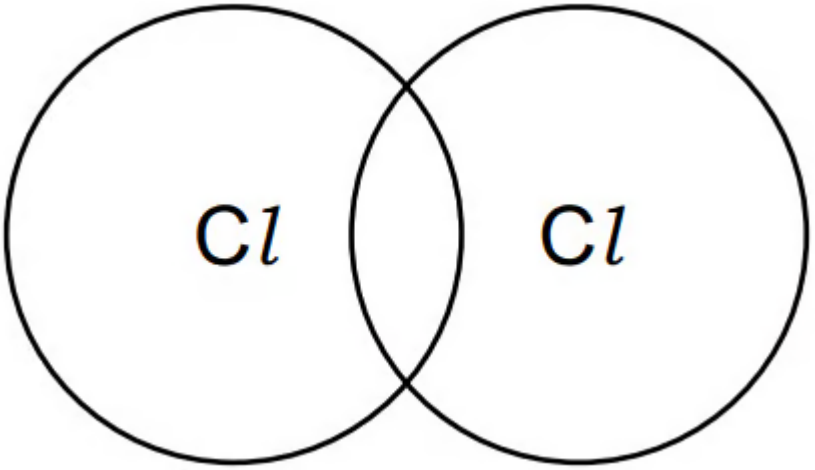
(1 mark)

(c) Aqueous chlorine reacts with aqueous potassium bromide as shown.

$$Cl_2 + 2KBr \rightarrow Br_2 + 2KCl$$

Complete the dot-and-cross diagram in **Figure 1.1** of a molecule of chlorine. Show outer shell electrons only.

Figure 1.1



(2 marks)

(d) Alkynes and alkenes are homologous series of unsaturated hydrocarbons. All alkynes contain a C≡C triple bond. Ethene and but-2-ene are alkenes.

Draw a dot-and-cross diagram to show a molecule of ethene, $CH_2=CH_2$. Show outer shell electrons only.

(2 marks)

4 (a) This question is about phosphorus and compounds of phosphorus. Phosphorus has the formula P_4. Some properties of P_4 are shown.

melting point / °C	45
boiling point / °C	280
electrical conductivity	non-conductor
solubility in water	insoluble

Name the type of bonding that exists between the atoms in a P_4 molecule.

.....

(1 mark)

(b) Explain, in terms of attractive forces between particles, why P_4 has a low melting point.

.....

(1 mark)

(c) Explain why phosphorus is a non-conductor of electricity.

.....

(1 mark)

(d) Phosphorus(V) oxide, P_4O_{10}, is an acidic oxide. Phosphorus(V) oxide, P_4O_{10}, reacts with aqueous sodium hydroxide to form a salt containing the phosphate ion PO_4^{3-}. Water is the only other product. Write a chemical equation for the reaction between phosphorus(V) oxide and aqueous sodium hydroxide.

.....

.....

(2 marks)

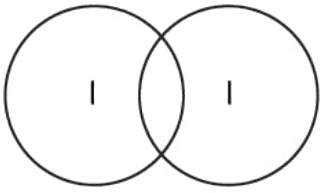
5 (a) Iodine and bromine are both halogens. The bonding in iodine is similar to the bonding in bromine.

Suggest **two** reasons why they bond in similar ways.

(2 marks)

(b) Complete the diagram below to show the bonding arrangement in a molecule of iodine.

Show the outer shell electrons only.



(2 marks)

(c) Explain why liquid iodine is unable to conduct electricity.

(2 marks)

(d) Iodine has an atomic number of 53 and xenon has an atomic number of 54.

Explain why xenon exists as an atom whereas iodine exists as a molecule.

(4 marks)

Hard Questions

1 (a) Separate: Chemistry Only

Selenium and sulfur are in Group VI. They have similar properties.

One of the main uses of selenium is in photoelectric cells. These cells can change light into electrical energy.

i) Name a process which can change light into chemical energy.

[1]

ii) Name a device which can change chemical energy into electrical energy.

[1]

.....

.....

(2 marks)

(b) Extended Only

The electron distribution of a selenium atom is 2 + 8 + 18 + 6.

i) Selenium forms an ionic compound with potassium. Draw a diagram which shows the formula of this ionic compound, the charges on the ions and the arrangement of the outer electrons around the negative ion. Use o to represent an electron from an atom of potassium. Use x to represent an electron from an atom of selenium.

[3]

ii) Draw a diagram showing the arrangement of the outer electrons in one molecule of the covalent compound selenium chloride. Use x to represent an electron from an atom of selenium. Use o to represent an electron from an atom of chlorine.

[3]

iii) Predict **two** differences in the physical properties of these two compounds.

[2]

(8 marks)

(c) Separate: Chemistry and Extended Only

The selenide ion reacts with water.

$$Se^{2-} + H_2O \rightarrow HSe^{-} + OH^{-}$$

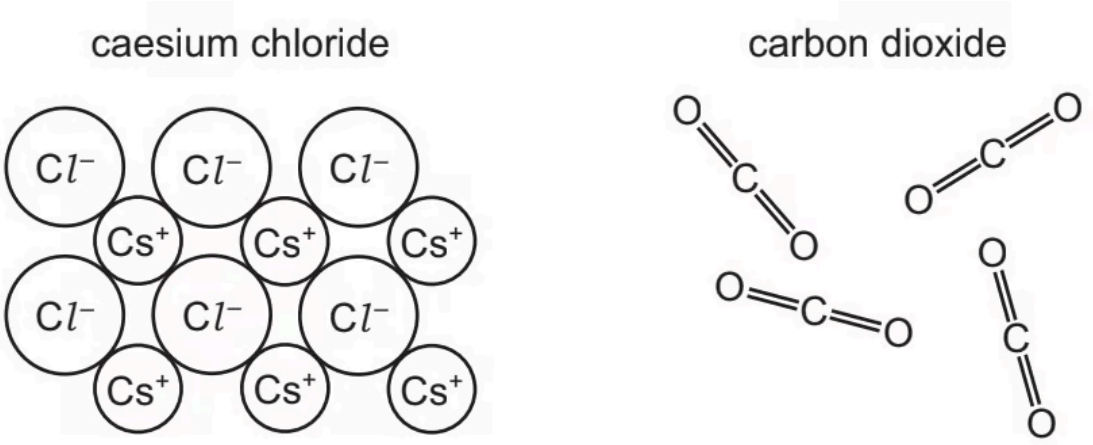
What type of reagent is the selenide ion in this reaction? Give a reason for your choice.

.....

.....

(2 marks)

2 (a) The diagram shows part of the structures of caesium chloride and carbon dioxide.



Describe both caesium chloride and carbon dioxide in terms of:

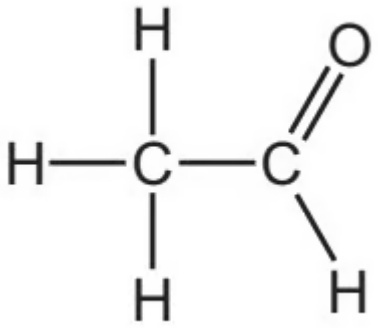
- bonding:
- arrangement of particles:

(5 marks)

(b) Extended Only

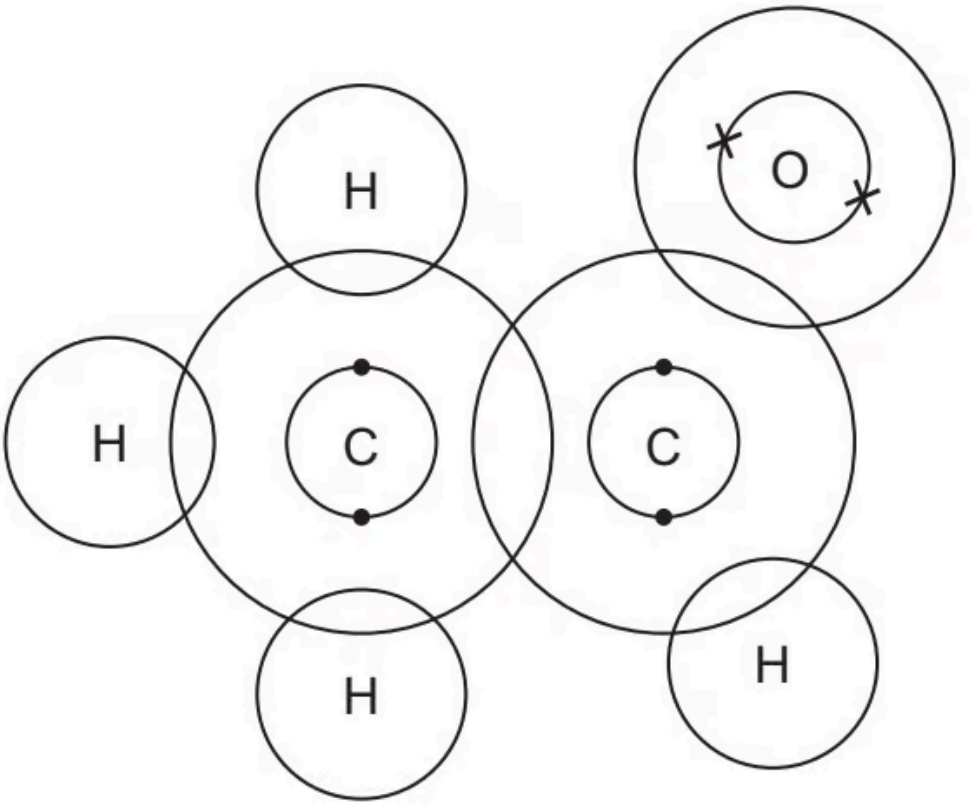
Ethanal is manufactured by two different processes.

The structural formula of ethanal is shown.



The C=O group in aldehydes is at the end of the carbon chain. This is a reactive part of the molecule.

Complete the dot-and-cross diagram to show the electron arrangement of a molecule of ethanal. Inner shells have been drawn.

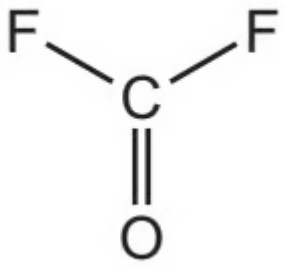


(3 marks)

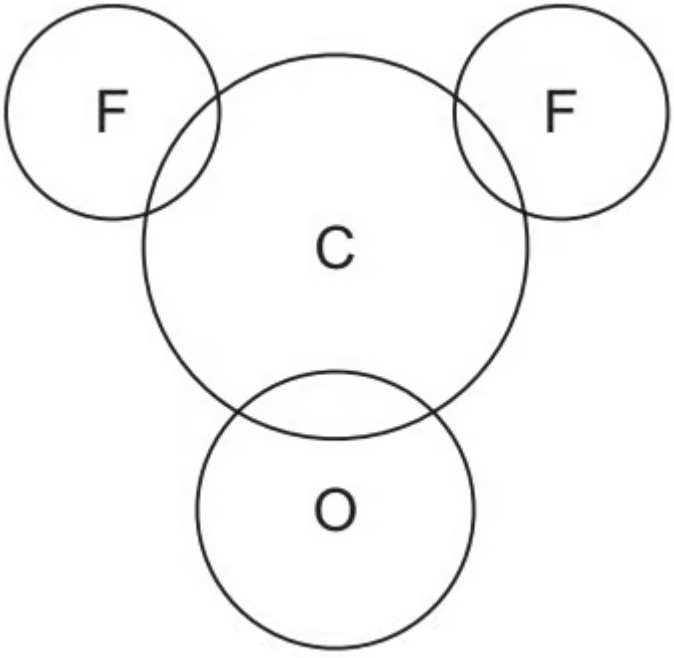
(c) Extended Only

Fluorine forms both ionic and covalent compounds.

Carbonyl fluoride, COF_2, is a covalent compound. The structure of a molecule of COF_2 is shown.



Complete the dot-and-cross diagram to show the electron arrangement in a molecule of carbonyl fluoride. Show outer shell electrons only.



(3 marks)

(d) Extended Only

The melting points of magnesium fluoride and carbonyl fluoride are shown.

	melting point / °C
magnesium fluoride	1263
carbonyl fluoride	–111

Explain, using your knowledge of structure and bonding, why carbonyl fluoride has a low melting point.

(2 marks)

3 (a) Phosphorous trichloride, PCl_3, bonds covalently.

Draw a dot-and-cross diagram to show the bonding in PCl_3. Show the outer electrons only.

(3 marks)

(b) Compare the bonding in phosphorous trichloride and ammonia.

(3 marks)

(c) Extended Only

Like nitrogen, phosphorus can exist as a diatomic molecule, diphosphorus, P_2, but it is unstable.

Suggest what type of covalent bond exists within diphosphorus.

(1 mark)

(d) Separate: Chemistry and Extended Only

The bond energy of the bond between the two nitrogen atoms within the nitrogen, N_2, molecule is 945 kJ/mol.

Suggest the bond energy of the bond between the two phosphorus atoms within the diphosphorus, P_2 molecule.

(1 mark)

4 (a) Extended Only

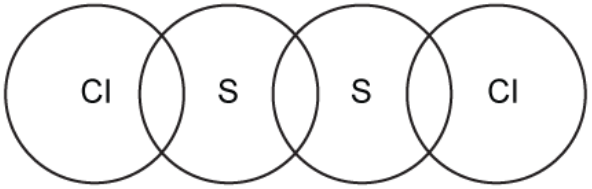
Sulfur monochloride, S_2Cl_2, has a simple molecular structure.

It was suggested that the structure of sulfur monochloride included a double covalent bond between the two sulfur atoms.

Suggest what is meant by the term *double covalent bond*?

(2 marks)

(b) After analysis of the structure of sulfur monochloride, S_2Cl_2, it was found that only single covalent bonds were present in its structure. Complete the diagram below to show the bonding arrangement in a molecule of sulfur monochloride. Show the outer shell electrons only.



(3 marks)

(c) Predict **two** properties of sulfur monochloride.

(2 marks)

(d) Sulfur monochloride can be produced in the laboratory by feeding chlorine gas into a flask containing sulfur in its elemental form, S_8. Write a balanced symbol equation for this reaction.

.....

.....

(2 marks)

5 (a) Extended Only

Methane, CH_4, and propane, C_3H_8, are both simple molecular compounds that are gases at room temperature.

Predict which of the two compounds has the higher boiling point. Explain your answer.

(4 marks)

(b) A carbon atom can form up to four covalent bonds. A hydrogen atom cannot form four hydrogen bonds.

State how many covalent bonds a hydrogen atom can form and explain why there is a difference.

(3 marks)

(c) Germanium also will form up to four covalent bonds.

Draw the dot-and-cross diagram of the simple molecule digermane,Ge_2H_6.

(2 marks)

(d) Extended Only

Explain why digermane does not conduct electricity.

.....

.....

(2 marks)