WJEC EDUQAS AS CHEMISTRY · COMPONENT 1

CHEMISTRY



EXAM QUESTION PACK

1.4 BONDING

SCORE	PERCENTAGE
/99	%

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1. When the temperature is increased, both solid iodine and diamond change directly into their gaseous state - they sublime.

(a) In each case, name the force or bond that is being overcome when the solid changes into a gas.

[2]

Iodine.....

Diamond.....

(b) State, with a reason, which solid would have the higher sublimation temperature.

[1]

(Total 3)

2. Explain each of the following observations concerning substances that you have met in your study of Chemistry.

(a) Aluminium has a higher melting temperature than sodium.
You should refer to the nature of the bonding.

[3] QWC [1]

(b) The colour of an aqueous solution of potassium iodide changes to brown when chlorine is bubbled through.
You should include an equation for the reaction that occurs.

[3]

(c) Ammonia was used as a refrigerant because it is relatively easy to liquefy. Ethane could not be used for this purpose.
You should refer to intermolecular forces.

[4]

(d) The reaction between methane and chlorine does not produce a pure sample of chloromethane, CH_3Cl.

You should include the name of the mechanism of the reaction involved and give an equation to show the formation of a product other than chloromethane. [3]

QWC [1]

Total [15]

3. Draw a dot and cross diagram to show the bonding in calcium fluoride. You should include outer electrons only and give any charges.

(Total 2)

4.

Aluminium, boron and nitrogen all form chlorides containing three chlorine atoms, XCl_3.

(a) Molecules of boron chloride, BCl_3, and molecules of nitrogen chloride, NCl_3, have different shapes.

Use VSEPR (valence shell electron pair repulsion) theory to state and explain the shapes of these molecules. [6]

QWC [2]

(b) The boron atom in boron chloride, BCl_3, is described as being electron deficient. Draw a dot and cross diagram for BCl_3 and use it to show what is meant by the term *electron deficient*. [2]

(c) Nitrogen chloride, NCl_3, is insoluble in cold water whilst the similar compound ammonia, NH_3, is very soluble. Explain this difference in behaviour. [2]

(d) Aluminium chloride, $AlCl_3$, forms a dimer that contains both covalent bonds and coordinate bonds. Describe what is meant by the terms *covalent bond* and *coordinate bond*. [2]

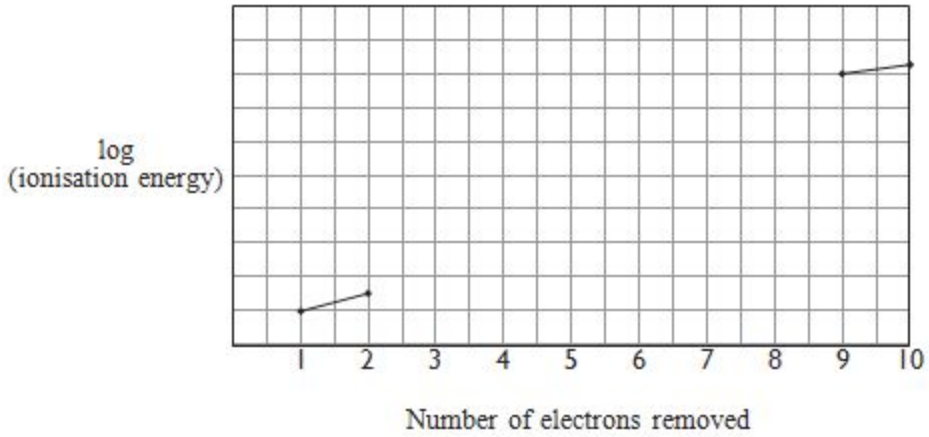
(Total 14)

5. The noble gases (Group 0) are a group of very unreactive elements. The first members of the group (helium, neon and argon) do not form any compounds, however it is possible to form a few compounds of krypton and xenon.

(a) Neon has ten electrons in each atom. The sketch below shows the first two and the final two ionisation energies for a neon atom.

(i) Sketch the pattern you would expect to see for the remaining six ionisation energies of neon.

[2]



(ii) Explain any significant changes in slope on the graph you have sketched.

[2]

(b) The first compound of a noble gas was formed from Xe atoms and PtF_6. It was the ionic compound $Xe^+ PtF_6^-$.

Explain why it is not possible to form a similar ionic compound of argon, $Ar^+ PtF_6^-$.

[2]

(c) Helium was identified in the Sun before it was discovered on Earth. When light from the Sun is split into its different colours by a prism, dark lines are observed against a coloured background which show the atomic absorption spectrum of helium. Explain how an atomic absorption spectrum forms.

[2]

(d) Xenon trioxide, XeO_3, is a compound which decomposes explosively at 25 °C according to the following equation.

$$2XeO_3(s) \longrightarrow 2Xe(g) + 3O_2(g)$$

Calculate the volume of gas, in dm^3, released by the decomposition of 1 mol of XeO_3 under these conditions. [2]

[1 mol of any gas at 25 °C occupies a volume of 24.0 dm^3]

Volume = ... dm^3

(Total 10)

6. (a) The Group 7 elements chlorine and iodine can both be produced from brine and can be used as disinfectants.

(i) Give the physical states of chlorine and iodine at room temperature. [1]

chlorine.....

iodine.....

(ii) State what is **observed** (if anything) when chlorine and iodine are added separately to potassium bromide solution. Write an equation for any reaction. [3]

Observations:

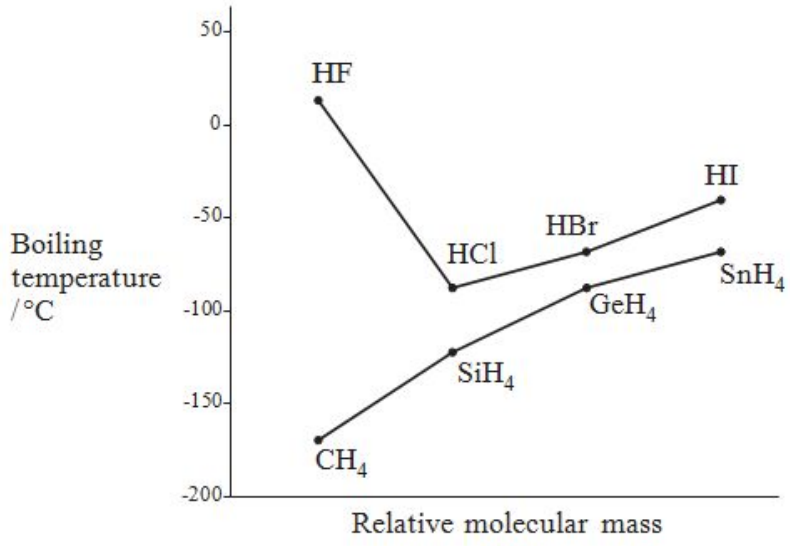
Equation(s):

(b) Chlorine can react with water to produce oxygen.

$$2Cl_2 + 2H_2O \longrightarrow 4HCl + O_2$$

Explain why this reaction is classified as a redox reaction. [2]

(c) The diagram below shows a plot of boiling temperature against relative molecular mass for the hydrides of Group 7 and Group 4.



(i) Describe the trends in boiling temperatures for the hydrides of Group 7 and Group 4, noting any anomalies.

[2]

(ii) By reference to the types of intermolecular force present, explain the shape of the plot for the hydrides of Group 7.

[3] QWC [1]

(iii) Suggest why the boiling temperature of HCl is greater than that of SiH_4. [1]

Total [13]

7. (a) Explain the fact that the melting temperature of sodium is much lower than the melting temperature of magnesium.
You should include reference to the type(s) of bonding involved and how this bonding affects melting temperatures. You may include a diagram if you consider it helpful. [3]

(b) In an experiment, 1-chlorobutane was heated with aqueous sodium hydroxide and the resulting solution was acidified. Aqueous silver nitrate was then added and a white precipitate was observed.
The experiment was repeated using 1-bromobutane and in this case a cream precipitate was observed.

Explain these observations.
You should include:

- the type of reaction that occurs between the halogenoalkane and sodium hydroxide
- an equation for this reaction
- the identity of the coloured precipitates.
- an equation to show the formation of these precipitates.

[4] QWC [1]

(c) Describe how the structures of sodium chloride and caesium chloride are similar and how they are different. Give a reason for any difference.You may include a diagram if you consider it helpful.

[3]

(d) When hydrogen bromide, HBr, is added to propene, C_3H_6, two different products are possible. In practice, however, more of one of the products is formed.
Explain why more of one product is formed.

You should:

- state the type of reaction involved
- identify the two possible products
- state which of the two products predominates.
- give the reason why more of this product is formed.

[4] QWC [1]

(Total 16)

8.

Haematite is an ore of iron that contains Fe_2O_3. Iron is extracted from this ore in a blast furnace.

(a) Balance the equation for the extraction of iron from Fe_2O_3. [1]

..... Fe_2O_3 + ... CO ⟶ ..... Fe + ... CO_2

(b) Use oxidation states to show that the reaction in *(a)* is a redox reaction. [2]

(c) A different oxide of iron is iron(II) oxide, FeO. The ions in this compound adopt an arrangement similar to that of sodium chloride.

(i) Give the crystal co-ordination numbers for the ions in FeO. [1]

(ii) Draw the arrangement of oxide ions around each iron ion. [1]

(d) Iron can be extracted from FeO according to the equation below.

$$FeO + CO \longrightarrow Fe + CO_2$$

Calculate the mass of iron that could be extracted from 20.0 kg of iron(II) oxide, FeO. [3]

Mass of iron = ... kg

(e) Carbon monoxide contains two covalent bonds and one co-ordinate bond. Explain what is meant by the terms ***covalent bond*** and ***co-ordinate bond***, indicating the difference between them.

[2]

(f) Iron is a typical metal. Describe the bonding present in iron. Explain how it can conduct electricity and why it has a high melting temperature.

[4] QWC [1]

(Total 15)

9.

The table below gives the electronegativity values of some elements.

Atom	H	N	O	Al	Cl
Electronegativity value	2.1	3.0	3.5	1.6	3.0

(a) Use the data in the table to identify any dipoles present in the following bonds. Mark their polarity clearly. [1]

N — H O — Cl

(b) Use the data to give a reason why aluminium chloride is considered to be a covalent compound, while aluminium oxide is an ionic compound. [1]

(Total 2)

10. Draw dot-and-cross diagrams to show the formation of calcium chloride from atoms of chlorine and calcium.

[2]

(Total 2)

11.

(a) The table below shows some physical properties of six carboxylic acids.

Acid	Formula	Boiling temperature / °C	Solubility in water
ethanoic	CH_3COOH	118	solubility decreasing ▼
propanoic	CH_3CH_2COOH	141	
butanoic	$CH_3(CH_2)_2COOH$		
pentanoic	$CH_3(CH_2)_3COOH$		
hexanoic	$CH_3(CH_2)_4COOH$	205	
heptanoic	$CH_3(CH_2)_5COOH$	223	

(i) Suggest the boiling temperature of butanoic acid.

[1]

(ii) Describe the trend in boiling temperature as the number of carbon atoms in the acids increases and suggest a reason for this effect.

[3]

(iii) Explain why the acids become less soluble in water as the sizes of the molecules increase.

[2]

(b) Calcium propanoate, $(CH_3CH_2COO)_2Ca$, is added to bread to prevent mould formation. It can be made from propan-1-ol by the following reactions.

$$CH_3CH_2CH_2OH \xrightarrow{\text{reagent(s)}} CH_3CH_2COOH \xrightarrow{\text{calcium hydroxide}} (CH_3CH_2COO)_2Ca$$

propan-1-ol — propanoic acid — calcium propanoate

(i) State the name of the reagent(s) used in the first stage. [1]

(ii) Propanoic acid, in its liquid state, exists as a dimer, where two molecules of the acid bond together using hydrogen bonding.

Draw the structural formula of this dimer and show the hydrogen bonding between the two molecules. [1]

(iii) In an experiment to make calcium propanoate, 50.0 cm^3 of a solution of propanoic acid of concentration 1.00 mol dm^{-3} was completely neutralised by calcium hydroxide.

I Calculate the number of moles of propanoic acid used. [1]

..... mol

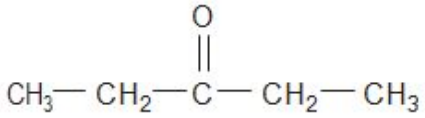
II State the number of moles of calcium hydroxide needed to just react with all the propanoic acid. [1]

..... mol

III Calculate the maximum mass of calcium propanoate ($M_r = 186$) which could be formed. [1]

..... g

(iv) Calcium propanoate produces pentan-3-one when it is strongly heated.



pentan-3-one

Write the displayed formula of **two** structural isomers of pentan-3-one. [2]

(c) A dicarboxylic acid, $HOOC—(CH_2)_n—COOH$, contains 49.3% of carbon and 43.8% of oxygen by mass. In both parts (i) and (ii) **show your working**.

(i) Use these figures to find the ratio of carbon atoms to oxygen atoms in the acid. [2]

Ratio C : O .....

(ii) Use this ratio to find the value of n in the formula of the acid.You are reminded that 1 molecule of the acid contains four oxygen atoms.

[1]

n = ...

(Total 16)

12.

Chlorine monofluoride has the following formula.

Cl — F

(a) Indicate the polarity in the bond shown by use of the symbols δ^+ and δ^-, giving a reason for your answer. [1]

(b) Draw a dot and cross diagram to illustrate the bonding between the two atoms in chlorine monofluoride. Include **all** *outer* shell electrons. [1]

2.

(a) Any 3 from 4 points:

Bonding is metallic (1)

This is **attraction** between the sea/ delocalised electrons and the positive ions (1)

Al^{3+} has more electrons in the sea than Na^+ / Al^{3+} has a higher charge density than Na^+ (1)

More energy is needed to overcome forces in Al (1) [3]

QWC: legibility of text; accuracy of spelling, punctuation and grammar; clarity of meaning [1]

(b) (Brown) iodine is formed (1)

Equation: $Cl_2 + 2I^- \rightarrow 2Cl^- + I_2$ / $Cl_2 + 2KI \rightarrow 2KCl + I_2$ (ignore state symbols) (1)

Chlorine is a better oxidising agent than iodi**ne**/ has a greater affinity for the electron/ chlorine has oxidised iod**ide** (1) [3]

(c) Ammonia is easily liquefied because it has a high boiling temperature (compared with ethane) (1)

Ammonia contains hydrogen bonds (1)

Ethane has van der Waals forces/ induced dipole-induced dipole forces (1)

Hydrogen bonds are stronger than van der Waals forces (1) [4]

(d) Reaction produces a mixture of halogenocompounds/ more than one halogen can be substituted / ethane (1)

The mechanism is (free) radical (1)

Any equation with product a polychloromethane/ ethane (1) [3]

QWC: selection of a form and style of writing appropriate to purpose and to complexity of subject matter [1]

Total [15]

3. 8 electrons in outer shell of all species/ 8 in two F and 0 in Ca (1)

2+ on calcium ion and 1- on fluoride ions (1) [2]

4. (a)
- BCl_3 is trigonal planar or clear diagram.
- NCl_3 is pyramidal or clear diagram.
- BCl_3 has 3 bonded pairs
- NCl_3 has 3 bonded pairs
- NCl_3 has a lone pair
- BCl_3 has no lone pair
- Electron pairs repel to be as far from each other as possible / position of minimum repulsion.
- Lone pairs repel more than bonded pairs.

First two points and any other 4 for (1) each up to 6 max [6]

- *QWC: selection of a form and style of writing appropriate to purpose and to complexity of subject matter.[1]*
-
- *QWC: legibility of text, accuracy of spelling, punctuation and grammar, clarity of meaning.[1]* [2]

(b)



accept crosses and dots exchanged (1)

Electron deficient: outer shell of boron has less than 8 electrons / is not full.(1) [2]

(c) NH_3 can form hydrogen bonds with water molecules (so it dissolves) (1)
NCl_3 cannot form hydrogen bonding. (1) [2]

(d)
- Covalent has a pair of shared electrons one from each atom (1)
- Coordinate has a pair of shared electrons both electrons from same atom (1)

[2]

Total [14]

5.

(a) (i) all ionisation energies showing gradual increase and one large jump (1)

large jump after 8 electrons (1) **[2]**

(ii) eighth and ninth electrons come from different shells (1)

ninth electron is closer to nucleus / has less or no shielding / has greater effective nuclear charge (1) **[2]**

(b) the compound formation has the noble gas atom being ionised (1)

ionisation energy of argon is much higher than that of xenon (1)

because the outer electron in argon is closer to the nucleus / has greater effective nuclear charge / shielding (1) - 2 max **[2]**

(c) electrons move from lower energy levels to higher energy levels (1)

by absorbing **specific frequencies** of light (1) **[2]**

(d) 1 mol of XeO_3 released 2.5 mol gas products (1)

2.5 mol of gas occupies 24.0 x 2.5 = 60.0 dm^3 (1) – follow through error (ft)

if candidates calculate the volumes of the two gases separately, then (1) for one gas volume correct and (1) for total volume correct **[2]**

Total [10]

6.

(a) (i) Chlorine – gas
Iodine – solid **[1]**

(ii) Chlorine – brown/orange solution (1)
Iodine – no change / no reaction (1)
$Cl_2 + 2KBr \longrightarrow Br_2 + 2KCl$ (1) **[3]**
(Accept ionic equation)

(b) Oxygen loses electrons therefore oxidised / oxidation state changes from -2 to 0 therefore is oxidised (1)

Chlorine gains electrons therefore reduced / oxidation state changes from 0 to -1 therefore is reduced (1) **[2]**

(c) (i) Boiling temperatures increase as relative molecular mass increases / number of electrons increases / down group (1)

HF has a higher boiling point than expected (1) **[2]**

(ii) Group 7 hydrides contain more dipole–dipole forces as group descended (1)

but HF contains hydrogen bonding between molecules (1)

Hydrogen bonds are stronger therefore HF's boiling temperature is greater / need more energy to break (1) **[3]**

QWC Selection of a form and style of writing appropriate to purpose and to complexity of subject matter *QWC* **[1]**

(iii) HCl more polar than SiH_4 therefore intermolecular forces are stronger / dipole greater in HCl / Cl more electronegative than Si **[1]**

Total [13]

7.

(a) both contain metallic bonds/ positive ions and delocalised electrons labelled on diagram (1)

those in magnesium are stronger/ harder to break/ need more energy to break (1)

because **2** electrons are involved in delocalisation/ attraction to the positive ions (1) [3]

(b) reaction is hydrolysis of halogenoalkane/ nucleophilic substitution of halogenoalkane (1)

$C_4H_9X + OH^- \rightarrow C_4H_9OH + X^-$ X can be Cl or Br (1)

(white precipitate is) silver chloride and (cream precipitate is) silver bromide (1)

$Ag^+(aq) + X^-(aq) \rightarrow AgX(s)$ or $AgNO_3 + X^- \rightarrow AgX + NO_3^-$ (1)

- state symbols ignored [4]

QWC selection of form and style of writing appropriate to purpose and to complexity of subject matter [1]

(c) caesium ions are bigger than sodium ions – accept 'atoms' (1)

co-ordination number 6 : 6 for sodium and 8 : 8 for caesium (1)

both cubic (1) [3]

(d) reaction is electrophilic addition (1)

two possible products are 1-bromopropane and 2-bromopropane (1)

more 2-bromopropane formed (1)

because of greater stability of intermediate positive ion/ 2° carbocation (1)

[4]

QWC legibility of text; accuracy of spelling, grammar and punctuation, clarity of meaning [1]

Total [16]

8.

(a) $1Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$ [1]

(b) Oxidation state of carbon at start = +2 and at end = +4 so it has been oxidised (1)
Oxidation state of iron at start = +3 and at end = 0 so it has been reduced (1)
Credit 1 mark if all oxidation states are given correctly with incorrect or no reference to what has been oxidised/reduced [2]

(c) (i) 6:6 [1]

(ii)

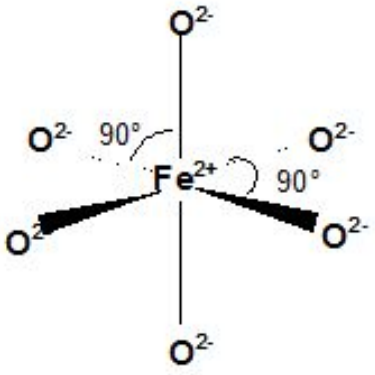


Diagram must be unambiguous, either by showing 3 dimensions, bond angles or through labelling, must identify iron and oxide as ions

[1]

(d) Moles FeO = 20,000 ÷ (55.8 +16) = 278.6 mol (1)
Moles Fe = moles FeO = 278.6 mol (1)
Mass Fe = 278.6 × 55.8/1000 = 15.5 kg (1) [3]

(e) Pair of shared electrons in both (1)

Covalent – 1 electron from each atom **and**
Co-ordinate – 2 electrons from same atom (1) [2]

(f) Lattice / regular arrangement of positive ions (1)
Sea of delocalised electrons (1)
Electrons can move to form an electrical current (1)
Strong forces / bonds between the delocalised electrons and the metal ions require a lot of energy to break / high temperature to overcome (1) [4]
QWC: selection of a form and style of writing appropriate to purpose and to complexity of subject matter [1]

Total [15]

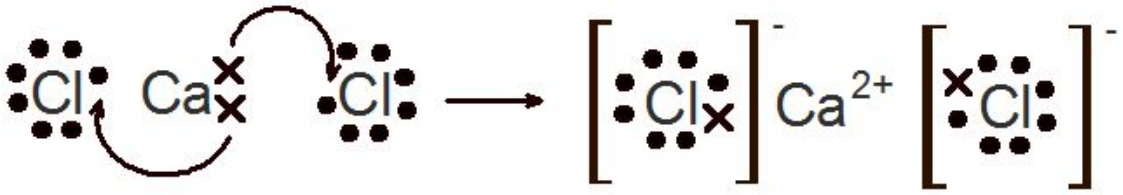
9.

(a) δ– N—H δ+ δ– O—Cl δ+ both for 1 mark [1]

(b) Difference in electronegativity is larger in aluminium oxide (so it is ionic) / the difference is smaller in aluminium chloride (so it is covalent) [1]

10.

1 mark showing movement of electrons; 1 mark showing dot and cross of $CaCl_2$ [2]



11.

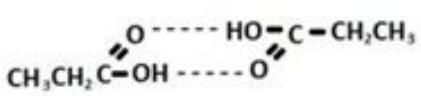
(a) (i) 165 ± 5 °C [1]

(ii) As the number of carbon atoms in the acids increase the boiling temperature increases (1)
This is due to an increase in induced dipole-induced dipole / Van der Waals forces (1) between molecules (1) [3]

(iii) As the molecules increase in size the relative importance of the —COOH group decreases (1)
There is therefore less of a tendency to hydrogen bond **with water** (becoming less soluble) (1) [2]

(b) (i) Acidified (potassium) dichromate (accept H^+, $Cr_2O_7^{2-}$) / Acidified (potassium) manganate(VII) (accept H^+, MnO_4^-) [1]

(ii)



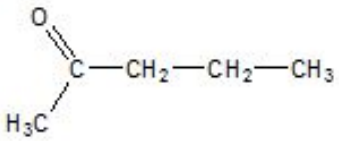
[1]

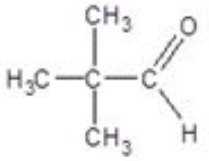
(iii) I 0.050 [1]

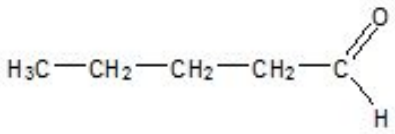
II 0.025 [1]

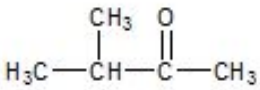
III 0.025 × 186 = 4.65 (g) [1]

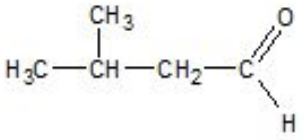
(iv) Any 2 of the following:

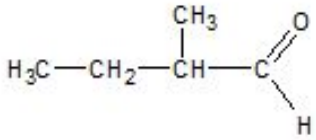












[2]

(c) (i) $\frac{49.3}{12} = 4.11$ $\frac{43.8}{16} = 2.74$ (1) Ratio of C:O is 3:2 (1) [2]

(ii) There are four oxygen atoms per molecule ∴ 6 carbon atoms (and 4 oxygen atoms)

∴ n = 6 – 2 in the acid groups ∴ n = 4 [1]

Total [16]

12.

(a) $Cl^{\delta+}$— $F^{\delta-}$

Electronegativity decreases down the group / fluorine is more electronegative (than chlorine) / chlorine is less electronegative (than fluorine) [1]

(b) [1]

