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VCE Chemistry ½
AOS 1 Revision I [1.12]
Contour Check Solutions

Contour Check

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Section A: [1.1] – Models of Atoms (Checkpoints) (26 Marks)

Sub-Section [1.1.1]: Describe the Composition of an Atom, & Write the Isotopic Symbol of an Element/Ion & Use It to Identify an Element's/Ion's Atomic & Mass Number

Question 1 (2 marks)

a. List out the types of subatomic particles that exist. (1 mark)

Protons, electrons, neutrons.

b. State how many protons, neutrons, and electrons the following has. (1 mark)

$^{39}_{19}K$

19 protons, 19 electrons, 20 neutrons.

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Question 2 (4 marks)

a. Explain why not all molecules are elements, giving an example for each case. (2 marks)

Not all molecules are elements because elements consist of molecules of the same element, which can also be an atom, like N_2, but molecules with different atoms, like H_2O are not considered elements.

b. For each of the following, state how many neutrons and electrons each atom has and state what type of ions it is.

i. $^{24}_{12}Mg^{2+}$. (1 mark)

12 protons, 10 electrons, 12 neutrons; cation.

ii. $^{35}_{17}Cl^{-}$. (1 mark)

17 protons, 18 electrons, 18 neutrons; anion.

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Question 3 (3 marks)

a. One student claims that a molecule must always be electrically neutral, but another argues that ions can also form molecules. Who is correct? Justify your answer. (3 marks)

The second student is correct because ions can form molecules in the form of polyatomic ions like SO_4^{2-}.

b. A student argues that the statement that atoms are the smallest possible unit of an element is untrue because of the existence of subatomic particles such as electrons and protons. Evaluate this student's arguments. (3 marks)

The student is incorrect because while atoms may not be the smallest possible unit of matter, atoms are the smallest possible unit of matter that can be classified as elements. A proton inside of a helium atom and a hydrogen atom are identical, but their atoms are different.

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Sub-Section [1.1.2]: Describe Bohr's Model of the Atom & Draw Shell Model Diagrams & Apply Emission Spectra to Bohr's Model of the Atom

Question 4 (1 mark)

a. When an electron falls back down to its ground state after being excited, what occurs, and how is it different for each atom?

Emission of light, and the colour of light emitted is determined by the difference in energy between the levels of the atom.

b. According to Bohr's model, an electron that moves between $n = 5$ and $n = 2$ emits higher energy light than an electron that falls between $n = 4$ and $n = 2$. Evaluate this statement.

This statement is true because as the shell number increases, the energy difference between $n = 0$ and that shell will also increase because it is further away from the nucleus.

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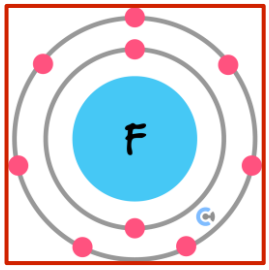
Question 5 (3 marks)

a. Draw the shell model diagram for an atom of fluorine. (1 mark)



b. How many electrons are in the valence shell of fluorine? (1 mark)

7 electrons

c. Explain the Octet Rule. (1 mark)

The valence shell of an atom can hold only eight electrons. All atoms want to fill their valence shell.

Question 6 (2 marks)

a. Explain what happens when an electron is excited past the highest possible shell it can occupy. (1 mark)

It escapes the atom entirely.

b. Suggest a way that we can observe this happening in real life. (1 mark)

Connect the element to a circuit because electrons are responsible for electricity, so we will see current flow (lightbulb circuit).

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Sub-Section [1.1.3]: Explain Schrodinger's Model of the Atom & Identify Differences Between His Model & Bohr's Model

Question 7 (2 marks)

What does the Schrödinger model of the atom say about the position of an electron within an atom?

The Schrödinger model states that electrons are not located in fixed orbits but instead exist in regions of space called orbitals.

Question 8 (3 marks)

Explain the relationship between the principal quantum number, n, the orbital type, and the total number of electrons that can exist in an energy level.

The principal quantum number n represents the energy level of an atom, or simply the number of shells. Each energy level contains orbitals corresponding to: s, p, d or f orbitals, each with different shapes and sizes. The total number of electrons that a shell can hold is $2n^2$, as each orbital holds a maximum of 2 electrons.

Question 9 (1 mark)

Which of the following statements about Schrödinger's model is NOT correct?

A. The exact position of an electron can be calculated using Schrödinger's equation.

B. Orbitals are regions of space where there is a high chance of finding an electron.

C. Schrödinger's model introduced the concept of quantum atomic nature.

D. The Schrödinger model uses math equations to describe electron behaviour.

Sub-Section [1.1.4]: Write Electron Configurations of Elements & Ions, in Both Ground & Excited States, Using Both Bohr & Schrodinger Models (Including Cu & Cr Exceptions & Condensed Notation)

Question 10 (1 mark)

Write the Bohr and Schrödinger electron configuration for potassium.

2,8,8,1 and $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

Question 11 (4 marks)

Schrödinger's electron configuration tells us a lot about where the electrons are orientated in an atom.

a. Write the Schrödinger electron configuration for chromium. (1 mark)

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$

b. Explain why chromium's electron configuration is written in that way instead of being conventional. (2 marks)

This is because half-filled subshells are more stable than partly-filled subshells.

c. Now, write the electron configuration of a chromium in an excited state. (1 mark)

$1s^2 2s^1 2p^6 3s^2 3p^6 4s^2 3d^5$

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Section B: [1.2] – Trends in the Periodic Table (Checkpoints) (29 Marks)

Sub-Section [1.2.1]: Explain Why the Periodic Table is Arranged the Way It is, With Respect to Blocks, Periods & Groups

Question 12 (2 marks)

State how valence electrons of an atom of nitrogen can be found by using the periodic table only.

By checking the group number it is in and taking the last digit of that. (e.g. for N is 5)

Question 13 (3 marks)

Consider the element of Rubidium.

a. State what block it is in and why. (2 marks)

Rb is in group 1 and this is because the highest energy subshell is an s-subshell.

b. Write its condensed Schrödinger electronic configuration. (1 mark)

$[Kr]5s^1$

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Question 14 (3 marks)

Consider the element of potassium, by only using the location of the following elements on the periodic table, state the following:

a. Number of electron shells it has. (1 mark)

4 shells

b. Number of valence electrons it has. (1 mark)

1

c. Subshell of highest energy it has. (1 mark)

s subshell

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Sub-Section [1.2.2]: Explain What the Terms 'Electronegativity, 'Atomic Radius', 'First Ionisation Energy', 'Metallic Character' & 'Non-Metallic Character' Mean, & Explain How They Vary Across a Period & Down a Group

Question 15 (3 marks)

For each of the following sets, rank them in terms of increasing atomic radius.

a. Mg, S, Si. (1 mark)

Si, S, Mg

b. K, Al, P. (1 mark)

P, Al, K

c. Cl, Br, F. (1 mark)

F, Cl, Br

Space for Personal Notes

Question 16 (3 marks)

a. Define electronegativity. (1 mark)

The ability of an atom to attract electrons towards itself.

b. Compare the electronegativity of oxygen and nitrogen. (2 marks)

Oxygen is more electronegative than nitrogen due to it having a higher effective nuclear charge.

Question 17 (4 marks)

a. Explain what is meant by the term 'metallic character'. (2 marks)

Metallic character describes an elements likelihood to lose electrons.

b. Explain why elements on the left side of the periodic table tend to have higher metallic character on the right side. (2 marks)

Elements on the left side of the periodic table have fewer valence electrons and larger atomic radii, making it easier for them to lose electrons. Conversely, elements on the right have smaller atomic radii and more valence electrons, making it harder to lose electrons.

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Sub-Section [1.2.3]: Find the Effective Nuclear/Core Charge of an Element, Explain How It Varies Across a Period & Down a Group, & Apply It to Other Trends Observed in the Periodic Table

Question 18 (3 marks)

a. Define 'core charge'. (1 mark)

Refers to the effective nuclear charge experienced by valence electrons.

b. For the following, state their effective nuclear charges:

i. Aluminium. (1 mark)

+3

ii. Chlorine. (1 mark)

+7

Question 19 (3 marks)

Explain how the concept of effective nuclear charge for the trend in electronegativity across a period.

As you move across a period, the number of protons in the nucleus increases while the number of shielding electrons remains constant. This results in a higher effective nuclear charge, meaning valence electrons experience a stronger attraction to the nucleus. This increased attraction causes electronegativity to increase across a period.

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Question 20 (5 marks)

a. Compare the effective nuclear charge of sodium and sulphur. Which one has a higher value? (1 mark)

Sulphur has a higher ENC.

b. Explain why sulphur has a smaller atomic radius than sodium, even though sulphur has more electrons. (2 marks)

Sulphur's higher effective nuclear charge pulls its electrons closer to the nucleus, reducing the atomic radius despite having more electrons. Sodium, with a lower effective nuclear charge, exerts less attraction on its valence electrons, resulting in a larger radius.

c. Based on the above, predict which element, sodium or sulphur, has higher electronegativity and explain your answer. (2 marks)

Sulphur would have a higher electronegativity because its higher effective nuclear charge allows it to attract bonding electrons more strongly than sodium.

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Section C: [1.3] – Metals & Covalent Lattices (Checkpoints) (28 Marks)

Sub-Section [1.3.1]: Explain the Metallic Bonding Model

Question 21 (3 marks)

The metallic bonding has several key features that define it.

a. What type of force exists between multiple metal atoms? (1 mark)

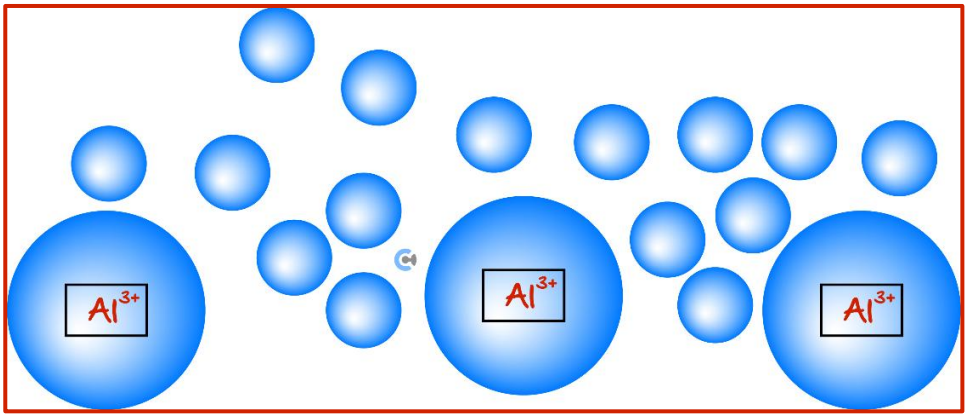
Electrostatic attraction/Covalent bonds.

b. Explain what a 'metallic character' is. (2 marks)

Metallic character is the tendency for the atom to lose electrons.

Question 22 (2 marks)

Draw the metallic lattice when you have 3 atoms of aluminium.



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Question 23 (5 marks)

Copper is a versatile metal extensively used in electrical wiring and other applications.

a. What type of metal is copper considered, and what is the usual charge of this metal? (1 mark)

Transition metal, Cu^{2+}

b. Identify a key feature of the metallic bonding model that enables copper to conduct electricity efficiently. (1 mark)

Delocalised sea of electrons and metal cations → Moving charges.

c. Describe how copper atoms would interact to form metallic bonds. (3 marks)

Copper atoms would first eject their valence electrons to ionise and become Cu^{2+}, these delocalised electrons would form a 'sea of delocalised electrons', which the copper cations will be attracted towards. This electrostatic attraction will arrange the copper atoms into a metal lattice.

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Sub-Section [1.3.2]: Identify Properties of Metals (High MP/BP, Electrical & Thermal Conductivity, Malleability & Ductility, Lustre)

Question 24 (1 mark)

Define the property of malleability.

Malleability refers to the property of metals being able to bend and alter its physical shape without breaking.

Question 25 (3 marks)

Between metals of potassium and sodium, explain which one would have a higher melting point and explain why.

As sodium has a smaller atomic radius than potassium, the electrons are closer to the nucleus and its attractive strength is stronger than potassium despite them both having the same ion charge of +1. Hence, sodium will have a higher melting point.

Space for Personal Notes

Question 26 (4 marks)

Most metals that you can think of often have a shiny 'metallic' look to them.

a. Explain this phenomenon. (2 marks)

Lustre due to the metallic lattice reflecting light back due to the moving charges.

b. Suppose that Alex is preparing to have a BBQ on his metal grill on a sunny day. If it had been sitting out in the sun for a few hours, what would happen if Alex touched the hood of the BBQ grill? (2 marks)

Alex would likely feel the high temperature as metals are good conductors of heat to the particles in the metallic lattice vibrating and transferring heat.

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Sub-Section [1.3.3]: Explain the Covalent Lattice Structures Bonding & Properties of Diamond & Graphite

Question 27 (1 mark)

Define what an allotrope is and give an example.

An allotrope is a way in which an element can exist by itself. e.g. graphite/diamond for carbon. Oxygen gas or Ozone gas for oxygen.

Question 28 (3 marks)

Explain what a sublimation point is and relate it to a carbon allotrope.

The carbon allotrope of diamond has really strong bonding in its covalent lattice and so it requires a large amount of thermal energy to break all the carbon covalent bonds. As such, when heating it up, the diamond will either exist in a state where the whole lattice exists or the lattice structure breaks entirely. Hence, it will go straight from a solid to a gas, which is sublimation.

Space for Personal Notes

Question 29 (6 marks)

Carbon exists in different forms with distinct properties.

a. Explain why graphite conducts electricity, but diamond does not. (2 marks)

Graphite conducts electricity because the carbon only uses 3 bonds and the last valence electron is ejected, forming a sea of delocalised electrons, resulting in the presence of moving charges in its covalent lattice, allowing electricity to be conducted. Whereas diamond utilises all 4 bonds, leaving no moving charge.

b. Which allotrope of carbon would you select for the purpose of sharpness and durability? Explain your answer. (2 marks)

Diamond, due to its covalent lattice being highly interconnected and strong as one carbon atom is always bonded to 4 other carbon atoms, resulting in very strong covalent bonds.

c. Explain what amorphous forms of carbon are. (2 marks)

Amorphous carbon are irregular, random arrangements of carbon that is the most common form of carbon present in wood, coal, etc.

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Section D: [1.4] – Metal Reactions & Recycling (Checkpoints) (32 Marks)

Sub-Section [1.4.1]: Write Balanced Equations for the Reactions Between a Metal & Oxygen & Between a Metal & Water, & Explain Any Relevant Implications of These Reactions

Question 30 (4 marks)

For the following metals, write their reaction with air.

a. Copper ionising with a 2 + charge. (1 mark)

$2Cu(s) + O_2(g) \rightarrow 2CuO(s)$

b. Cobalt ionising with a 2 + charge. (1 mark)

$2Co(s) + O_2(g) \rightarrow 2CoO(s)$

c. Tin ionising with a 4 + charge. (1 mark)

$Sn(s) + O_2(g) \rightarrow SnO_2(s)$

d. Potassium. (1 mark)

$4K(s) + O_2(g) \rightarrow 2K_2O(g)$

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Question 31 (2 marks)

Write the equation for the reactions that occur when the following metals are dipped into a tub of water.

a. Barium. (1 mark)

$Ba(s) + 2H_2O(l) \rightarrow Ba(OH)_2(s) + H_2(g)$

b. Calcium. (1 mark)

$Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(s) + H_2(g)$

Question 32 (4 marks)

a. Write the reaction that occurs when aluminium reacts with oxygen in air. (1 mark)

$4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$

b. Now, write the reaction that takes place when aluminium reacts with water. (1 mark)

$2Al(s) + 6H_2O(l) \rightarrow 2Al(OH)_3 + 3H_2(g)$

c. Pure aluminium is often painted over with a plastic coating to help preserve the condition of the aluminium for longer. Explain this observation. (2 marks)

This is due to the plastic coating that will help the aluminium not be in contact with the oxygen in the air, preventing it from reacting and forming aluminium oxide.

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Sub-Section [1.4.2]: Apply Trends in the Periodic Table to Metal Reactivity

Question 33 (4 marks)

For the following pairs of metals, state which is more reactive.

a. Sr and Be. (1 mark)

Sr

b. Li and Na. (1 mark)

Na

c. Al and Mg. (1 mark)

Mg

d. Ni and Fe. (1 mark)

Fe

Question 34 (3 marks)

Between sodium and lithium, which one requires more energy to extract?

As sodium is more reactive than lithium due to having an extra electron shell and hence lower first ionisation energy, this means that it is harder to separate the metal into its pure form because it does not form naturally and is hard to maintain in its pure form once attained.

Question 35 (5 marks)

Consider precious metals like gold and silver.

a. It's a common saying that you can shower with pure gold and silver jewellery. Use your knowledge of chemistry to explain this phenomenon. (3 marks)

Gold and silver are most likely unreactive metals and as such they will not react to water as easily as other metals like iron.

b. Given the properties of expensive metals, what form do you suggest that they are found naturally? (2 marks)

Gold and silver are most likely found in their pure form as they are unreactive and hence stable, they won't react easily to air or water.

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Sub-Section [1.4.3]: Explain How Metals are Obtained & Recycled, & their Associated Advantages & Disadvantages

Question 36 (2 marks)

Why are groups 1 & 2 metals not used in the industry?

These metals are too reactive and unstable due to having. 1 or 2 valence electrons and thus, are not stable enough to be used as substances fit for recycling.

Question 37 (3 marks)

Not all metals are recycled in industry. For example, many phones are disposed of rather than recycled for their precious metals. Suggest a possible reason for this phenomenon.

Some waste has small amounts of many different metals; thus, it is difficult and uneconomic to recover all of these metals, which are only present in small amounts.

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Question 38 (5 marks)

a. Explain why extracting metals from ores requires more energy compared to recycling metals instead. (3 marks)

Extracting metals from ores requires breaking strong chemical bonds in their natural forms as oxides, which demand high temperatures and large amounts of energy to maintain this state. Hence, it would use up a lot of energy, especially for industrial amounts of metal. Recycling bypasses this process, as we are using metals that are already in their "pure" form, we spend energy trying to reshape them into the specific usages that we would like, which takes much less energy since that can be done at lower temperatures.

b. Discuss a disadvantage associated with metal recycling. (2 marks)

A disadvantage associated with metal recycling is that if something that is being recycled has many different parts to it with different metals and other non-metal materials like plastic, it can be energy-intensive to sort them correctly and may not be economically feasible to do on a large scale. An example of this would be recycling smartphones for precious metals.

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Section E: [1.5] – Ionic Compounds (Checkpoints) (39 Marks)

Sub-Section [1.5.1]: Write the Formula of Simple & Complex (Containing Polyatomic and Transition Metal Ions) Ionic Compounds and be Able to Name Them

Question 39 (4 marks)

Write the formula for the ionic compound that is formed between the following:

a. Na and NO_3^-. (1 mark)

$NaNO_3$

b. K and SO_4^{2-}. (1 mark)

K_2SO_4

c. CO_3^{2-} and Mg. (1 mark)

$MgCO_3$

d. SO_3^{2-} and Ca. (1 mark)

$CaSO_3$

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Question 40 (4 marks)

Find the valency of the metal ion in the following ionic compounds:

a. $Fe_2(SO_4)_3$. (1 mark)

Fe^{3+}

b. $AgCl_2$. (1 mark)

Ag^{+}

c. $Sn(NO_3)_4$. (1 mark)

Sn^{4+}

d. CuBr. (1 mark)

Cu^{+}

Space for Personal Notes

Question 41 (6 marks)

For each of the following ionic compounds, find the valency for all of the elements in the compound:

a. $K_2Cr_2O_7$. (2 marks)

$K = +1, O = -2, Cr = +6$

b. $Ag(NH_3)_2^{\pm}$. (2 marks)

$Ag = +3, N = -3, H = +1$

c. $[Pt(NH_3)_4]Cl_2$. (2 marks)

$Pt = +2$
$N = -3, H = +1, Cl = -1$

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Sub-Section [1.5.2]: Explain the Structure of Ionic Compounds and be Able to Draw Electron Transfer Diagrams

Question 42 (3 marks)

Write the formula of the compound formed from calcium and oxygen, naming the compound and explaining how this compound exists in real life.

CaO, calcium oxide. This compound exists in real life as an ionic lattice comprising of Ca^{2+} ionically bonded to O^{2-} which has a dull appearance.

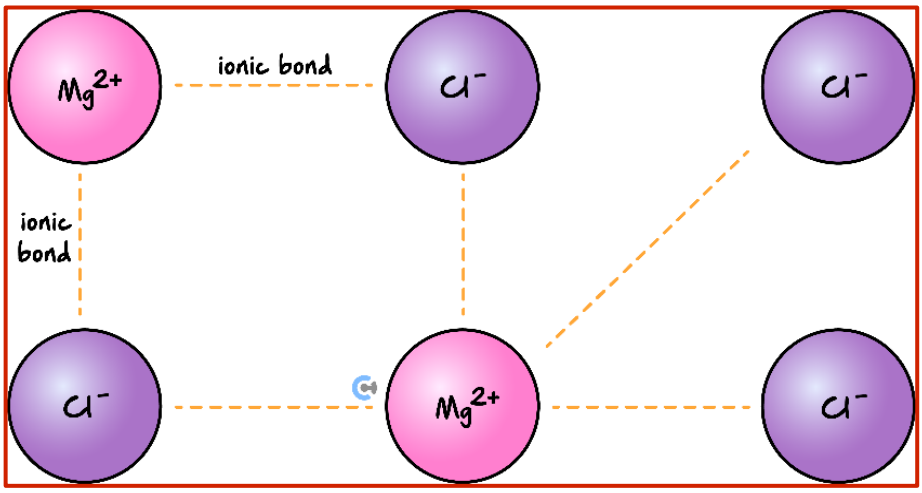
Question 43 (4 marks)

You're exploring ionic compounds in your chemistry project and encounter magnesium chloride.

a. Write the molecular formula. (1 mark)

$MgCl_2$

b. Draw the ionic lattice structure of magnesium chloride, showing at least two magnesium ions and four chloride ions. Label the forces between the ions. (3 marks)

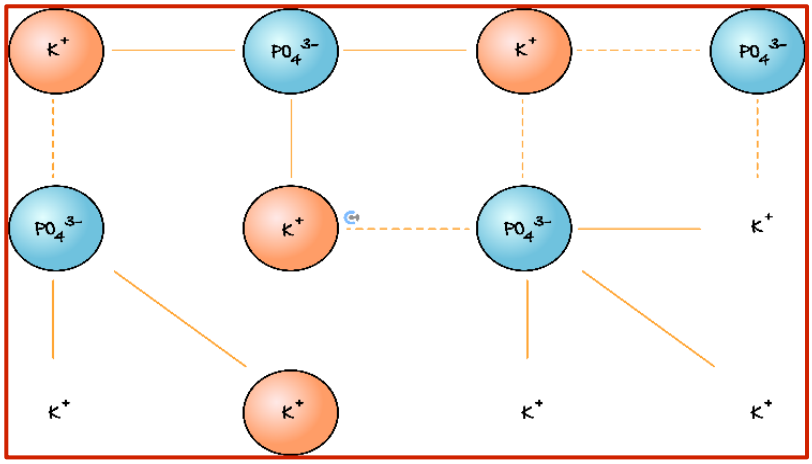


Question 44 (7 marks)

a. What is the molecular formula and name of the compound that forms between phosphate ions and potassium ions? (2 marks)

K_3PO_4 - Potassium phosphate

b. Draw the ionic lattice structure that forms above, showing at least two sets of the substance according to the molecular formula. (3 marks)



c. Compare the bonding present in **part b.** with the bonding that is present within a molecule of HCl. (2 marks)

Inside K_3PO_4 will have ionic bonding whereas HCl is covalently bonded. Covalent bonding involves the sharing of electrons whereas ionic bonding involves donating and accepting electrons to form an intramolecular bond.

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Sub-Section [1.5.3]: Explain the Properties of Ionic Compounds (Hardness, High MP/BP, Brittleness, Electrical Conductivity in Various States), With Reference to Their Structure and Bonding

Question 45 (3 marks)

Explain what happens when a block of $NaNO_3$ is struck with an external force, stating the property this phenomenon can be described with.

When $NaNO_3$ is struck with a force, the molecules will shift and as they are originally aligned to their opposite charges in order to maintain the ionic lattice, when a force strikes it, the charges won't be opposite anymore. Hence, the charges repel and the ionic lattice structure will break, resulting in ionic compounds being brittle.

Question 46 (3 marks)

Between the same amount of molecules of NaCl and $CuCl_2$, explain which one would have a higher boiling point.

$CuCl_2$ would have a higher boiling point as for the same number of molecules, the charges between Na and Cl would be $+1$ and -1 respectively, but for $CuCl_2$ it would have to double the charges for the positive and negative ions. Hence, there is greater electrostatic attraction in the ionic lattice of $CuCl_2$ compared to NaCl, and hence it would require more energy to break apart. Therefore, $CuCl_2$ has a higher boiling point.

Space for Personal Notes

Question 47 (5 marks)

Consider a block of copper and a block of salt.

a. Explain why a solid block of copper can conduct electricity, however, when we use a block of salt, it doesn't work. (3 marks)

The block of copper is arranged in a metal lattice so as such there are free-moving electrons that can conduct charge, whereas a block of NaCl all the ions are packed closely together in an ionic lattice and hence it is not able to have any free charges to be transferred, and as such will not be electrically conductive.

b. Suggest and explain how salt could conduct electricity. (2 marks)

Salt can become electrically conductive when it is dissolved in a solution. This is because the Na^+ and the Cl^- structure will no longer be packed tightly and as they can move freely, they can then conduct electricity as they are moving charges themselves.

Space for Personal Notes

Section F: [1.6] – Covalent Molecules (Checkpoints) (32 Marks)

Sub-Section [1.6.1]: Draw Lewis Structures of Atoms & Covalent Molecules

Question 5 (4 marks)

State how many covalent bonds the following molecules can form:

a. Silicon. (1 mark)

4

b. Iodine. (1 mark)

1

c. Phosphorus. (1 mark)

3

d. Krypton. (1 mark)

0

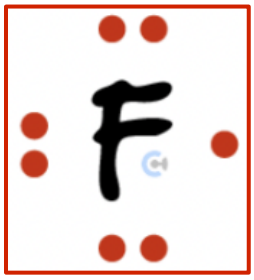
Space for Personal Notes

Question 6 (5 marks)

a. Draw the Lewis structure for the following:

i. Selenium. (1 mark)

ii. Fluorine. (1 mark)



b. What is the likely formula of the molecule formed between carbon and sulphur? Explain. (3 marks)

CS_2. This forms due to Carbon needing to gain. 4 electrons but each S needs 2 electrons, hence 2 sulphurs will doubly bond to the carbon to ensure all atoms gain a full outer shell.

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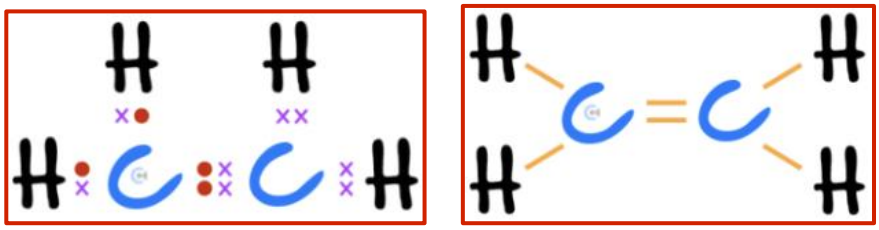
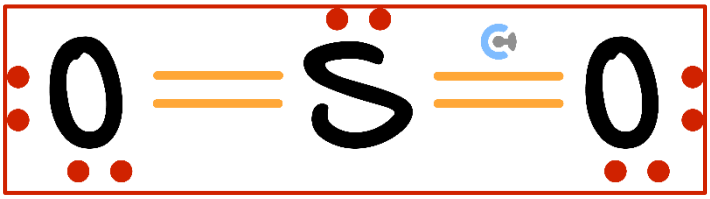
Question 7 (6 marks)

For the following, draw their Lewis structures:

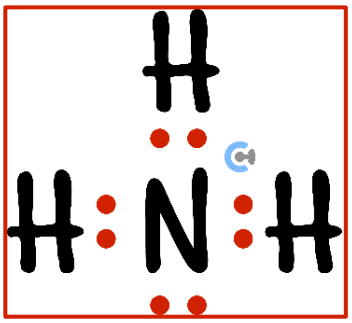
a. C_2H_4. (2 marks)



b. Sulphur dioxide, SO_2. (2 marks)



c. NH_3. (2 marks)



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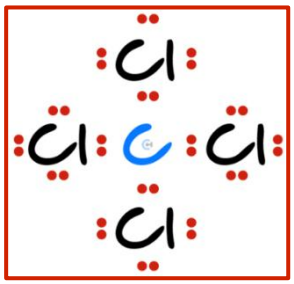
Sub-Section [1.6.2]: Identify the Geometries (Parent & Molecular) of Molecules, With Reference to VSEPR Theory

Question 12 (8 marks)

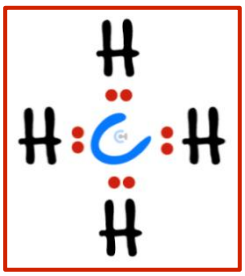
Draw the Lewis structures of the following and state their molecular geometry:

a. CCl_4. (2 marks)



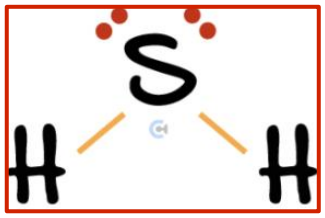
Tetrahedral

b. CH_4. (2 marks)



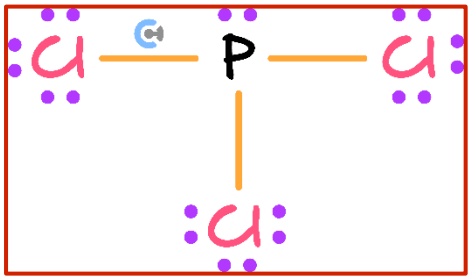
Tetrahedral

c. H_2S. (2 marks)



V-Shaped/Bent

d. PCl_3. (2 marks)



Pyramidal

Question 13 (4 marks)

a. For the following, state their molecular geometry.

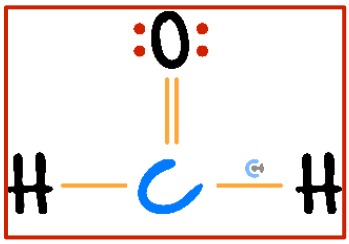
i. BF_3. (1 mark)

Trigonal Planar

ii. H_2Se. (1 mark)

V-Shaped/Bent

b. Draw the Lewis structure for CH_2O and state its molecular and parent geometry. (2 marks)



Trigonal planar for both.

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Question 14 (5 marks)

Answer the following questions regarding the VSEPR theory:

a. Briefly explain the VSEPR theory. (2 marks)

Valence Shell Electron Pair Repulsion Theory is a theory that states electron pairs want to be as far away from each other as possible, informing us of a molecule's geometry and 3D shape.

b. Explain why a trigonal planar molecular geometry for a molecule with 4 total electron pairs is not possible. (3 marks)

A trigonal planar geometry is dictated by having 3 total electron pairs in a molecule, so if a molecule has 4 total electron pairs, then the trigonal planar would not be possible. 4 total electron pairs but 3 bonding pairs will result in a pyramidal molecular geometry not a trigonal planar.

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Section G: [1.1 – 1.6] – Overall (VCAA Qs) (62 Marks)

Question 48 (3 marks)

Tick whether the following statements are **true** or **false**:

Statement	True	False
a. Oxygen is highly reactive because it has six valence electrons and needs two more to complete its valence shell.	✓	
b. Alkali metals, such as sodium, tend to form +2 ions when they react with nonmetals.		✓
c. The atomic radius decreases as you move down a group in the periodic table.		✓
d. Fluorine is the most electronegative element on the periodic table.	✓	
e. The ionisation energy of elements generally decreases as you move from left to right across the period.		✓
f. The noble gas neon has a stable electron configuration and does not form chemical bonds typically.	✓	

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Question 49 (3 marks)

Explain why the allotrope of graphite is very hard in one direction but very soft and weak in the other direction, with reference to its structure and bonding.

As graphite is a covalent layer lattice, it has covalent bonds within a layer of graphite which is very strong. However, the bonding between layers is just intermolecular bonding (dispersion forces) as carbon is not electronegative. As covalent bonds are much stronger than dispersion forces, the intralayer bond strength is much higher than the interlayer bond strength. As such, graphite is very hard in one direction because of covalent bonds, but weak in another direction due to the dispersion forces.

Question 50 (5 marks)

a. Explain which metal is most likely to react out of potassium, lithium and aluminium. (3 marks)

Potassium is the most likely to react because not only does it have the lowest effective nuclear charge it also has the largest atomic radius, rendering its first ionisation energy to be the lowest and hence, easiest to react.

b. We understand that inside of a phone, there are trace amounts of valuable metals such as gold. However, evaluate whether it is viable to extract these metals when we recycle phones. (2 marks)

No, it is not viable since it is very expensive to extract it and the actual amounts are too small to make it feasible.

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Question 51 (4 marks)

For each of the following, determine the valency of the elements in the compound:

a. MnO_4^-. (2 marks)

$Mn = +7$ and $O = -2$

b. $Fe_2(SO_4)_3$. (2 marks)

$Fe = +3, S = +6, O = -2$

Question 52 (3 marks)

Draw the Lewis structure for NOBr and state its molecular geometry and parent geometry.

V-Shaped/Bent (molecular) trigonal planar (parent)

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Question 53 (4 marks)

State the molecular geometry of the following.

a. CH_2ClF. (2 marks)

Tetrahedral

b. NOBr. (2 marks)

V-Shaped/Bent

Question 54 (4 marks)

Consider an atom represented using Bohr's model.

a. When an excited electron exists at $n = 5$, what are all the ways that it can fall back to its ground state? (2 marks)

5 0 4 0 3 0 2 0 1
5 0 1
5 0 4 0 2 0 1
5 0 4 0 1
5 0 3 0 2 0 1
5 0 3 0 1
5 0 2 0 1

b. What is the observation when an electron takes a particular path against other paths? (2 marks)

The difference in energy will result in different colour light being emitted when the electron drops back down to its ground state.

Question 55 (7 marks)

You are given the following clues about four unknown metals A, B, C, and D:

- Metal A has one valence electron.
- Metal B has a smaller atomic radius than A.
- Metal C has the highest number of delocalised electrons among the four metals.
- Metal D has the weakest metallic bonding of all four metals.

a. Given the metals are either potassium, lithium, copper or francium, state the identities of the metals. (3 marks)

A = Potassium
$B = \text{Li}, C = \text{Cu}, D = \text{Fr}$

b. Can the strongest metal that you have stated in **part a.** be hammered into thin sheets? In your answer, include the name of this property. (2 marks)

Yes, as all metals are malleable, since when a force is struck onto a metal lattice even though the cations move it will still be attracted to the delocalised electrons, maintaining electrostatic attraction.

c. Why would you consider metallic bonding to be stronger than dispersion forces? (2 marks)

Yes, because dispersion forces are temporary dipoles between partial charges whereas metallic bonding is an electrostatic attraction between full

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Question 56 (6 marks)

Consider a block of aluminium and a block of NaCl.

a. When a block of aluminium and a block of NaCl are both struck with an external force, compare and explain what happens to each block. (3 marks)

Aluminium as it has a metallic lattice the metal cations will be moved but will still be attracted to the delocalised electrons and hence the lattice will change shape but remain intact. Whereas NaCl if struck by a force, the ionic lattice will be misaligned, which results in electrostatic repulsion as like charges are next to each other and therefore it will shatter, making NaCl brittle.

b. Now, compare their relative electrical conductivities and state how each one would conduct if it all. (3 marks)

In solid form, only Al can conduct electricity as it contains free moving charges as the electrons are delocalised, whereas NaCl does not have any free moving charges in its ionic lattice and hence will not conduct electricity. However, in molten or aqueous form, the NaCl will ionise into Na^+ and Cl^- and therefore will be free-moving charges, and can then conduct electricity in that form. However, the Al will be more electrically conductive overall.

Question 57 (3 marks)

Between a block of sodium metal compared to a block of aluminium metal, which one would you expect to have a higher boiling point?

Aluminium would have a higher boiling point than sodium due to the fact it has a +3 charge compared to sodium's +1 charge. This means in the metal lattice, the attraction between Al ions and electrons are stronger because of the larger charge. Hence, it will take more energy to dismantle aluminium's lattice compared to sodium and therefore Al will have a higher boiling point.

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Question 58 (11 marks)

Shipbuilding is an activity that requires careful consideration of materials because metals can degrade very quickly from water contact.

a. Write the reaction that would occur between zinc and water, assuming zinc becomes an ion with a 2 + charge. (1 mark)

$Zn(s) + 2H_2O(l) \rightarrow Zn(OH)_2(s) + H_2(g)$

b. How does zinc's reactivity compare with potassium? (2 marks)

Zinc is less reactive than potassium due to potassium having a lower effective nuclear charge making it easier to remove its valence electron and hence make it react.

c. Consider the situation where we have a block of zinc oxide.

i. What do we observe if we slice this block in half? (2 marks)

Initially, the block will appear as pure zinc because it hasn't reacted with the oxygen in the air yet however, moments after the zinc will react with oxygen in the air to produce zinc oxide and therefore it will become duller.

ii. If we wanted a zinc block to not become zinc oxide on the outside but remain pure, suggest a strategy that would help. (1 mark)

Coat it with a material that resists the zinc from reacting with oxygen such as paint or plastic coating.

d. A sample of zinc metal is being tested for its suitability to use on a ship, and the crew accidentally dropped the metal when transporting. Are we still able to use it? Explain. (3 marks)

Yes, we can since zinc is malleable, and to revert it to the original shape we can just apply the force in the exact opposite direction because the metallic lattice will remain intact due to the cations being attracted to electrons regardless of whether a force has been struck.

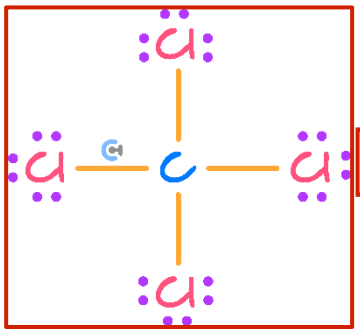
e. The outside of a ship will usually be constructed with metal, but if it were to travel through a storm, evaluate whether constructing the deck out of metal is a smart idea. (2 marks)

No, because metals are electrically conductive, meaning that if lightning strikes the electricity will travel throughout the ship including the deck, which may pose as a safety hazard for the crew on the ship.

Question 59 (9 marks)

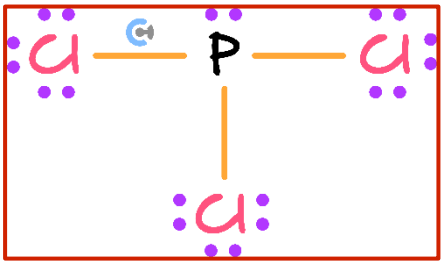
A chemist is studying two different molecules for their applications in pharmaceuticals.

a. One of the studied compounds is CCl_4. Draw its Lewis structure and state its molecular geometry. (2 marks)



Tetrahedral

b. Another molecule PCl_3 is investigated. Draw its Lewis structure and state its parent and molecular geometry. (2 marks)



Parent: tetrahedral, Molecular: Pyramidal

c. Describe the similarities between their geometries, if any. (2 marks)

Their parent geometries are both tetrahedral because the PCl_3 has a lone pair on the P on top.

d. Based on their structures, describe which one would have a more even electron distribution than the other. (3 marks)

CCl_4 has the same number of electrons on all sides of the carbon itself, meaning that the electrons are essentially symmetrical around the carbon whereas the PCl_3 atom has a lone pair on the topside of the P, but then the Chlorines are more electronegative than the P so it would result in the electrons in the bonds being pulled towards the Cl more so than the P. As the direction of the chlorines are not symmetrical, this results in PCl_3 being imbalanced.

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