HSC Chemistry

Chemical Monitoring and Management

Term 1 – Week 7

Student name: ……………………………….

Class code: ……………………………………..

Teacher name: ……………………………….

DUX College

T: (02) 8007 6824
E: info@duxcollege.com.au
W: www.duxcollege.com.au

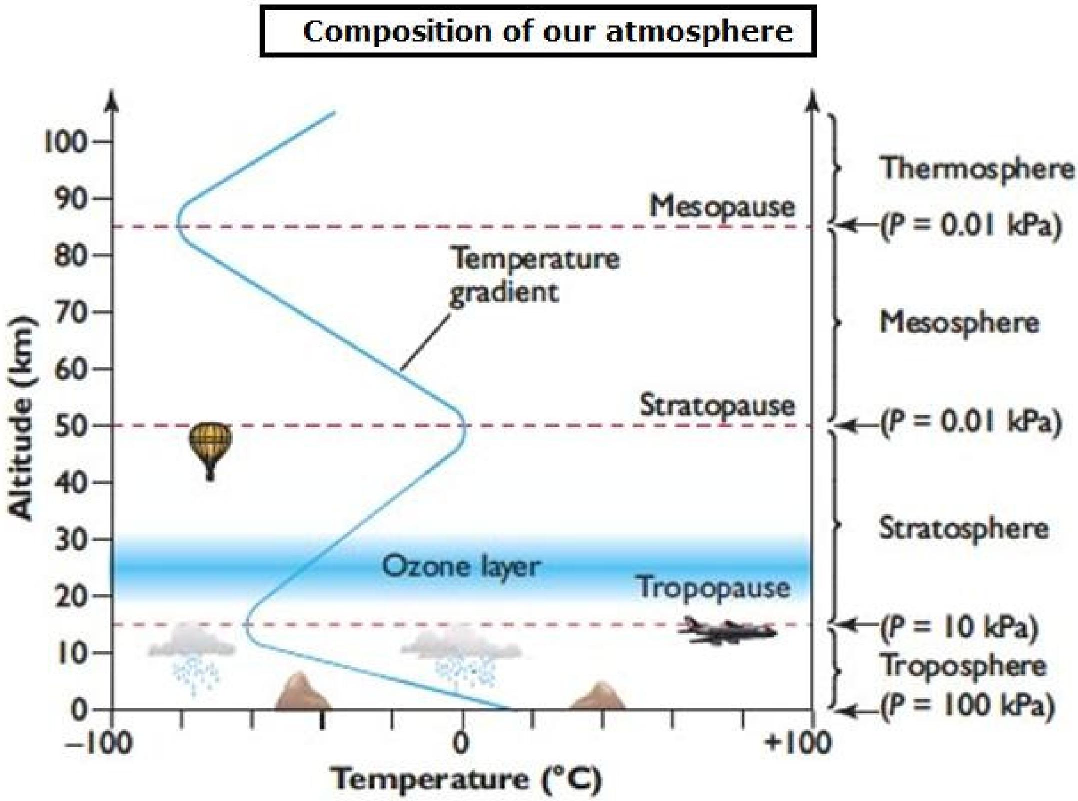
Term 1 – Week 7 – Theory

Human activity has caused changes in the composition and the structure of the atmosphere. Chemists monitor these changes so that further damage can be limited

- <u>**Describe the composition and layered structure of the atmosphere**</u>

Structure of Earth's atmosphere

The Earth's atmosphere comprises of layers of gas surrounding the Earth. It is 200 to 300 km thick, depending on external influences such as seasonal factors. In terms of the atmosphere's mass, 75% of the mass is in the lower 15km and over 99% of the mass being below 90km from the surface of the Earth. Atmospheric pressure decreases quickly as altitude increases.



The atmosphere has a layered structure, separated into many 'spheres' which are defined due to temperature trends as altitude changes. In order from closest to the ground, they are:

- Troposphere (where we live in. Rain clouds and normal planes fly within this sphere)
- Stratosphere (ozone layer and special planes, like the concorde, fly in this sphere)
- Mesosphere (absorbs radio waves during the day)
- Thermosphere (the last sphere of our atmosphere. Full of ionised particles from absorbing sunlight)

Troposphere: The troposphere is the region of the atmosphere closest to the Earth. It extends from sea level to 15km above sea level, with temperature decreasing as altitude increases. As a region with rising and falling air, the troposphere has weather, temperature, pressure and moisture variations. Gases are well mixed here due to convection.

Stratosphere: The stratosphere is the region of the atmosphere above the troposphere, and separated from the troposphere by the tropopause. Its altitude extends from 15km to 50km above sea level. The stratosphere is significant as it contains the ozone layer, which absorbs UV radiation from the sun. Temperature increases as altitude increases in the stratosphere due to reactions involving ozone which are exothermic in nature. As the temperature rises as altitude rises, there is little convection of gases and the stratosphere experiences little weather, being very stable.

Mesosphere: Above the stratosphere exists the stratopause and then the mesosphere, extending from 50km to 85km above sea level. In the mesosphere, temperature decreases as altitude increases.

Thermosphere: Above the mesosphere is the thermosphere, separated by the mesopause. The thermosphere occupies the region 85km to 600km above sea level. In the thermosphere, temperature increases as altitude increases, accounted for the absorption of solar radiation by oxygen molecules. In the thermosphere, many atoms are ionised by the solar wind.

Constituents of Earth's atmosphere

The atmosphere is composed primarily of the gases of nitrogen, oxygen and argon. Nitrogen makes up 78.08% of the atmosphere, oxygen 20.95% and argon 0.93%. The remaining 0.04% is made up of other gases, such as carbon dioxide, helium, methane, hydrogen, nitrogen oxides, ammonia and sulfur dioxide. Many of these have been released from human industries.

- **Identify the main pollutants found in the lower atmosphere and their sources**

There are a number of pollutants found in the lower atmosphere such as carbon dioxide, nitrogen oxides and sulfur dioxide, covered in the Acidic Environment. These pollutants in the lower atmosphere have both natural and human sources, as detailed in the table below

Lower atmosphere pollutant	**Sources**	**Effects**
NO_x	Combustion engines, excessive use of nitrogen fertilisers, bacterial action in soil	Produces acid rain, photochemical smog and ozone, some forms are respiratory irritants
Ozone	Produced from NO_x, produced from lightning strikes	Strong oxidant and respiratory irritant. (Ozone is good in the ozone layer, as it blocks UV, but it is bad in the lower atmosphere, as it is a pollutant)
SO_2	Combustion of fuel with sulfur impurities (power plants, coal trains, fossil fuels), metal extraction from sulfide ores (e.g. copper ores), geothermal hot springs, volcanoes, oxidation of hydrogen sulfide	Poisonous and irritating gas, produces acid rain (sulfurous acid)
CO	Incomplete combustion of fuel (old car engines), bushfires, volcanoes, bacterial decomposition of organisms	Irritant to the respiratory system
CO_2	Complete and incomplete combustion of fuel (cars, trucks, trains, power plants)	Contributes to the greenhouse effect, otherwise harmless
Volatile Organic Compounds	Industry, vehicles and households (e.g. unburnt hydrocarbons, industrial solvent vapours etc)	Some are carcinogenic (cancer-causing) and some are respiratory irritants
Particulates	Combustion, industrial processes such as mining and asbestos dust	Some are respiratory irritants and some are carcinogenic

- **Describe ozone as a molecule able to act both as an upper atmosphere UV radiation shield and a lower atmosphere pollutant**

Ozone is an allotrope of the element oxygen and is a pale blue and toxic gas. In the lower atmosphere, it is harmful to human life. However, it is essential acting as an upper atmosphere UV radiation shield.

In the lower atmosphere, ozone is a **dangerous pollutant** to humans. It causes breathing difficulties, aggravates respiratory problems, increases susceptibility to infection and produces headaches and premature fatigue. It is also highly reactive, capable of oxidising many substances. Ozone is a component of photochemical smog, which causes unsightliness in cities.

Ozone is beneficial to humans in the upper atmosphere. In the stratosphere, **ozone absorbs harmful UV radiation**. This high energy radiation is harmful to humans, as it causes skin cancers, eye cataracts, sunburn, damages plants and decreases our immune response. By absorbing this harmful radiation, ozone is **essential to the wellbeing** of life on Earth.

Therefore, ozone is beneficial in the upper atmosphere, but undesirable in the lower atmosphere.

- **Describe the formation of a coordinate covalent bond**
- **Demonstrate the formation of coordinate covalent bonds using Lewis electron dot structures**

Co-ordinate covalent bonds

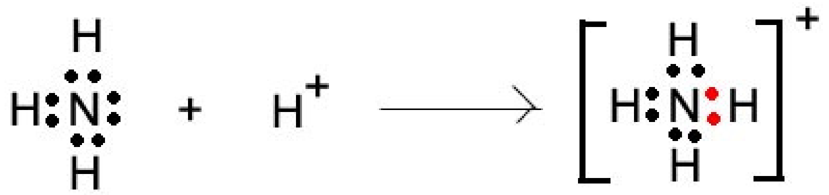
A coordinate covalent bond is defined as a covalent bond in which **both of the shared electrons come from the one atom**, as opposed to an ordinary covalent bond, where a pair of electrons are shared between two atoms, with each atom sharing one electron with the other atom.

Although a coordinate covalent bond is formed differently from an ordinary covalent bond, once it is formed it is identical in strength as an ordinary covalent bond.

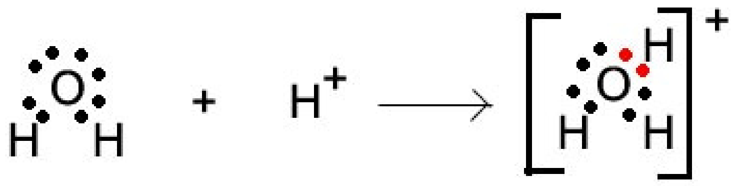
Formation of co-ordinate covalent bonds

There are many examples of the formation of coordinate covalent bonds using Lewis electron dot structures.

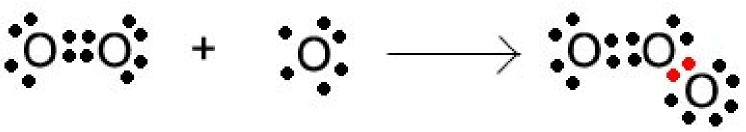
For example, ammonia is a molecule with a central nitrogen atom attached to three hydrogen atoms by normal covalent bonds. When it reacts with a hydrogen ion, a coordinate covalent bond is formed. The hydrogen ion contains no valence electrons to share with nitrogen, and shares two electrons from nitrogen to fill its valence shell. The formed product is the **ammonium ion**.



Another example of the formation of a coordinate covalent bond is when a hydrogen ion attaches itself to the oxygen atom of a water molecule to form the **hydronium ion**.



A further example is the formation of **ozone**, which is formed when an oxygen free radical reacts with diatomic oxygen gas, forming a coordinate covalent bond.



- **Compare the properties of the oxygen allotropes O_2 and O_3 and account for them on the basis of molecular structure and bonding**

An allotrope is a different form of an element. O_2 and O_3 are allotropes with different properties in many aspects. These differences in properties are the result of the differences between these two allotropes in terms of their molecular structure and bonding.

Property	**O_2**	**O_3**
Physical description	Colourless, odourless gas essential for living organisms	Colourless gas with poisonous and distinctive odour
Boiling point	-183°C	-111°C
Melting Point	-219°C	-193°C
Density	1.331g/L	1.998g/L
Water solubility	Sparingly soluble	More soluble than diatomic oxygen
Reactivity	Reacts with most other elements to form oxides and is a moderately strong oxidising agent	Much more reactive than diatomic oxygen and is a very strong oxidising agent
Stability	Very stable	Easily decomposed into O_2
Shape	Linear	Bent
Uses	Combustion, life support, steel making, liquid rocket fuel	Sterilisers in food shops and kitchens, water purification, bleaching, disinfectant

Differences in terms of bonding structure

Ozone is more reactive than oxygen and is less stable. This is because when molecular oxygen reacts, the **double bond must be broken** which requires considerable energy. When ozone reacts, only a **single bond needs to be broken** in order to liberate the third oxygen atom, leaving behind an O_2 molecule. The energy required for this process is significantly lower than that required to split up molecular oxygen. As a result, ozone reacts more easily and is less stable than molecular oxygen. This also explains the high oxidising potential of ozone, as it can attach and extremely reactive oxygen free radical to complex carbon molecules in living matter to start a series of reactions that lead to the breakdown of biological compounds.

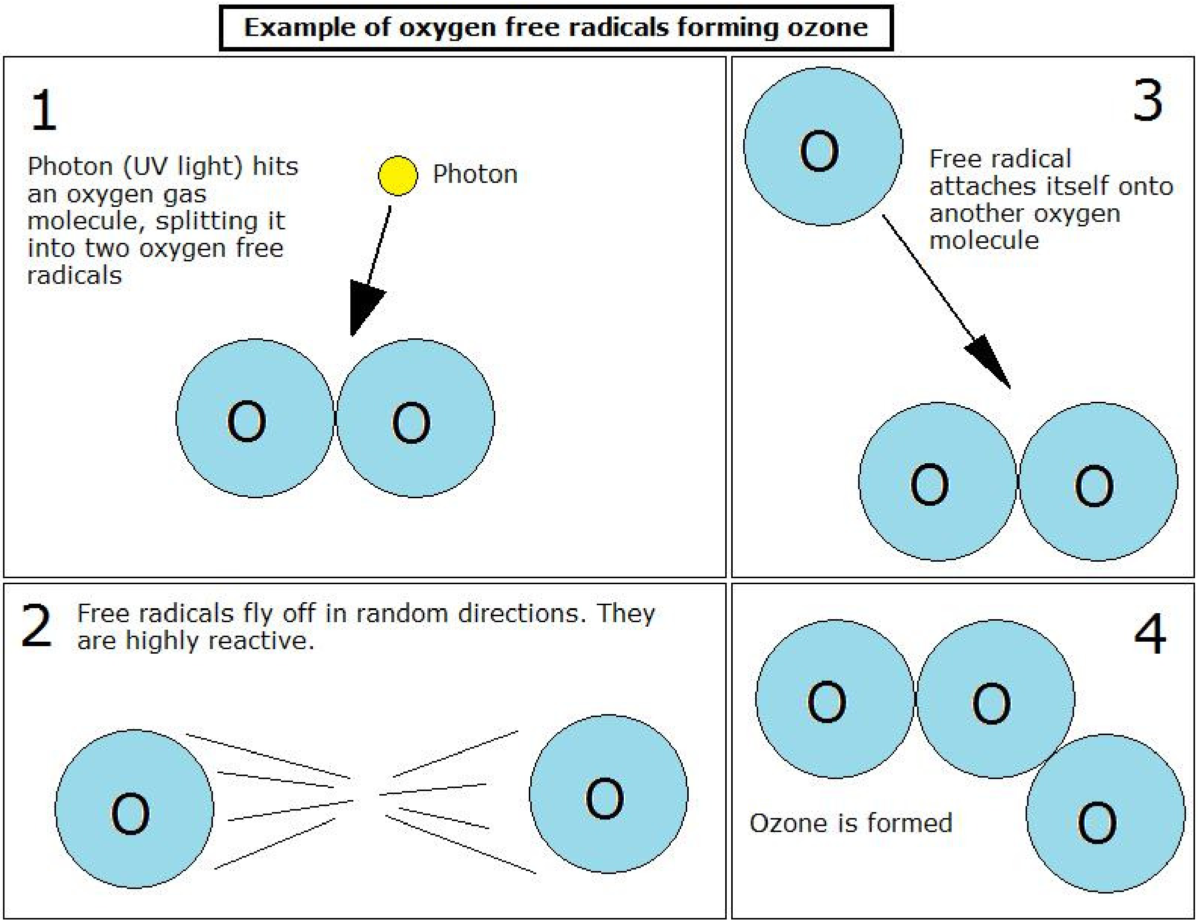
The boiling and melting points of ozone is higher than that of oxygen, because **ozone has greater intermolecular forces** which must be overcome during the process of boiling and melting. Ozone has a **greater molecular mass** than oxygen, leading to greater dispersion forces, while its bent shape means it has greater polarity than oxygen with a linear shape and subsequently, **greater dipole-dipole forces**. Together, this leads to the greater intermolecular forces present in ozone compared to oxygen. The greater dipole in ozone also makes it more soluble in water, as the greater dipole-dipole interactions with water allow it to be dissolved more easily.

- **Compare the properties of the gaseous forms of oxygen and the oxygen free radical**

Oxygen free radical

A free radical is a molecule or single atom that contains an **unpaired electron**. The oxygen free radical is the oxygen atom with unpaired electrons and energy levels higher than ground state. Remember that electrons want to pair up, and when chemical bonds form, it is actually electrons pairing up. An oxygen free radical is therefore simply an unbonded free oxygen atom O.

They are formed by UV light separating O_2 into two oxygen free radicals, or by UV light separating O_3 into O_2 and an oxygen free radical.



Greater reactivity of free radicals

Due to their unpaired electrons and energy levels higher than the ground state, The oxygen free radical is **highly reactive**, much more so than both ozone and gaseous oxygen. It is an extremely toxic as they react quickly with organic molecules in living cells. Because the lone O wants to gain an extra electron to form a pair, it will rip any electron it comes into contact with, hence making it highly reactive.

Oxygen and ozone are relatively stable in the atmosphere unless acted on by UV radiation. In contrast, oxygen free radicals exist only briefly before reacting with other molecules. Because

Need help?
Visit the student forums and ask our tutors.
www.duxcollege.com.au/forums
T: (02) 8007 6824
E: info@duxcollege.com.au
W: www.duxcollege.com.au

oxygen free radicals are so unstable, its properties such as melting point, boiling point and water solubility are unable to be measured. As soon as oxygen free radicals touch something (even something as stable as water) it will rip off an electron and attach itself, forming a new molecule.

- **Identify the origins of chlorofluorocarbons (CFCs) and halons in the atmosphere**

CFCs	**Halons**
Chlorofluorocarbons (CFCs) are compounds containing chlorine, fluorine and carbon only. CFCs have been released into the atmosphere from human activities. When CFCs are decomposed by UV light, they **release chlorine free** radicals. From the 1950s, CFCs were used on large scales as an alternative refrigerant to ammonia. CFCs were non toxic, unreactive and readily liquefied making them **ideal as refrigerants in refrigerators and air conditioners**. As well, they found other uses such as **propellants in spray cans**, in dry cleaning and in blowing agents. From these multiple uses, CFCs were released into the atmosphere in large amounts during our history.	Halons are compounds composed of bromine, fluorine, chlorine and carbon only. They are **similar to CFCs**, but release bromine radicals rather than chlorine radicals when decomposed in the atmosphere. Halons are **used in fire extinguishing systems**, as **solvents and in cleaning agents**. From these uses, halons were released into the atmosphere. Although these two types of chemicals have seen their use decline from the Montreal Protocol, their **long atmospheric life** means a significant amount of these chemicals still exist in the atmosphere.

- **Identify and name examples of isomers (excluding geometrical and optical) of haloalkanes up to eight carbon atoms**

Isomers are compounds with the **same molecular formula but different structural formulae**. Isomers do not necessarily share similar physical or chemical properties.

For this module, students need to recall the naming rules for carbon compounds, and apply these rules specifically to naming haloalkanes. This should be **revision** as we have covered hydrocarbon naming in Production of Materials.

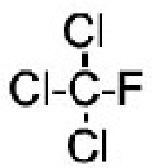
Naming rules

For all straight chain halogenated haloalkane, naming follows the following rules:

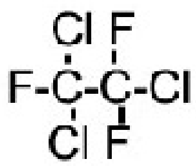
1. Bromo-, chloro-, fluoro- and iodo- are used as prefixes to the haloalkane name if present in the haloalkane.
2. The position of the halogen atom is denoted by a number. If more than one of a particular type of halogen atom is present, prefixes such as di-, tri-, tetra- etc. are used in front of the halogen prefix (in step 1).
3. The location number of each halogen is given, with numbering starting from one side such that the sum of all location numbers is the **lowest possible number**. If numbering starting from either side gives the same lowest possible number, then numbering starts from one side such that the lowest number is given to the halogen that comes first alphabetically.
4. If more than one type of halogen is present in the hydrocarbon, they are listed alphabetically.
5. The name of the haloalkane comes at the end of the name, with the name determined by the number of carbon atoms in the haloalkane. (E.g. 2,3-dichlorohexane, if there are 6 carbon atoms)

Examples of naming haloalkanes

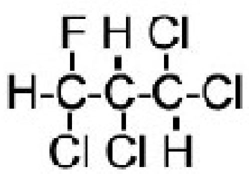
Trichlorofluoromethane



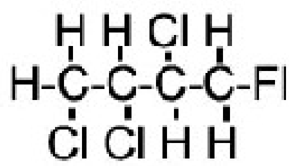
1,1,2-trichloro-1,2,2-trifluroethane



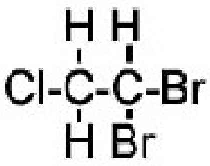
1,1,2,3-tetrachloro-3-fluoropropane



1,2,3-trichloro-4-fluoropropane



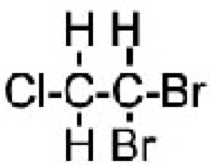
1,1-dibromo-2-chloroethane



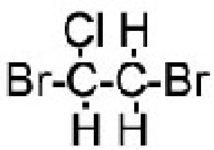
Examples of haloalkane isomers

Isomers are compounds with the same molecular formula but **different structural formulae**. For example:

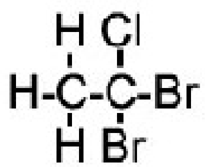
1,1-dibromo-2-chloroethane



1,2-dibromo-1-chloroethane



Above is 1,2-dibromo-1-chloroethane, an isomer of 1,1-dibromo-2-chloroethane. Note how the same number of each type of atom is present, but the molecule has a different structural formula and different name.



Above is another isomer, 1,1-dibromo-1-chloroethane. There are **many possible combinations** for each given haloalkane.

Term 1 – Week 7 – Homework

Human activity has caused changes in the composition and the structure of the atmosphere. Chemists monitor these changes so that further damage can be limited

- **<u>Describe the composition and layered structure of the atmosphere</u>**

1. List the three most common gases in the atmosphere in descending order. **[1 mark]**

……

……

2. Identify a layer of the atmosphere where temperature generally increases with altitude. **[1 mark]**

……

3. Identify the layer of the atmosphere where the greatest concentration of ozone is found. **[1 mark]**

……

4. Describe temperature changes in the atmosphere as one ascends from the surface of the Earth. **[2 marks]**

……

……

……

……

5. Describe changes in pressure in the atmosphere as one ascends from the surface of the Earth. **[2 marks]**

……

……

……

……

6. Describe why gases take long periods of time to diffuse over the tropopause from the troposphere to the stratosphere. **[2 marks]**

……

……

……

……

7. Outline why there is significant weather in the troposphere but very little weather activity in the stratosphere. **[2 marks]**

……

……

……

……

8. Name in order the three layers of the atmosphere closest to the Earth's surface. **[2 marks]**

……

……

……

- **Identify the main pollutants found in the lower atmosphere and their sources**

1. Identify THREE main pollutants found in the lower atmosphere. **[2 marks]**

……

……

……

……

2. For the three pollutants named above, explain why they are considered a pollutant to human society. **[2 marks]**

……

……

……

……

3. For the three pollutants named above, identify their natural and human sources. **[2 marks]**

………

………

………

………

4. Select one pollutant named above and construct a balanced chemical equation showing how the pollutant is produced. **[1 mark]**

………

………

5. Explain why carbon monoxide and carbon dioxide are considered pollutants in the lower atmosphere. **[3 marks]**

………

………

………

………

………

………

6. Identify ways by which the concentration of the pollutants found in the lower atmosphere can be measured. **[2 marks]**

………

………

………

………

- **Describe ozone as a molecule able to act both as an upper atmosphere UV radiation shield and a lower atmosphere pollutant**

1. Explain why ozone can be considered beneficial to human society. **[2 marks]**

……

……

……

……

2. Explain why ozone can be considered harmful to human society. **[2 marks]**

……

……

……

……

3. Identify where ozone is harmful and beneficial to human society. **[1 mark]**

……

……

4. List THREE problems associated with the exposure to ozone. **[2 marks]**

……

……

……

……

5. List THREE problems associated with high energy UV radiation reaching the Earth's surface. **[2 marks]**

……

……

……

……

- **Describe the formation of a coordinate covalent bond**
- **Demonstrate the formation of coordinate covalent bonds using Lewis electron dot structures**

1. Define 'covalent bond'. **[1 mark]**

……

……

2. Define 'coordinate covalent bond'. **[1 mark]**

……

……

3. Describe the similarities and differences between normal and coordinate covalent bonds. **[2 marks]**

……

……

……

……

4. Describe, with examples, the formation of coordinate covalent bonds. **[2 marks]**

……

……

……

……

5. Construct Lewis electron dot diagrams representing the following substances: carbon monoxide, nitrogen gas, boron trifluoride. **[2 marks]**

……

……

……

……

6. Construct Lewis electron dot diagrams representing the following substances: ozone, hydronium, ammonium and clearly indicate the coordinate covalent bond in the diagram. **[2 marks]**

7. Nitrous oxide, N_2O has the atoms arranged such that nitrogen is the central atom, surrounded by a nitrogen and an oxygen atom. Draw a Lewis electron dot diagram for nitrous oxide. (Hint: there is a co-ordinate covalent bond between the oxygen atom and the central nitrogen atom) **[2 marks]**

8. Nitrous acid has the atoms arranged in its molecular structure as: HONO. Construct a Lewis electron dot diagram for nitrous acid. **[1 mark]**

9. Nitric acid has the atoms arranged as: HOONO. Construct a Lewis electron dot diagram for nitric acid. **[1 mark]**

10. Construct a Lewis electron dot diagram for hydrogen chloride, HCl. **[1 mark]**

11. Construct a Lewis electron dot diagram for the following substances and identify any single covalent, double covalent and coordinate covalent bonds: sulfur dioxide, sulfur trioxide **[2 marks]**

- **<u>Compare the properties of the oxygen allotropes O_2 and O_3 and account for them on the basis of molecular structure and bonding</u>**

1. Define 'allotrope' **[1 mark]**

……….

……….

2. Contrast the two allotropes of oxygen in terms of their formulas and the bonding present in the molecules. **[2 marks]**

……….

……….

……….

……….

3. Contrast the two allotropes of oxygen in terms of their reactivity and potential as oxidising agents. **[3 marks]**

……

……

……

……

……

……

4. Explain why oxygen gas has a low melting and boiling point than ozone. **[3 marks]**

……

……

……

……

……

……

……

5. Identify the shape of oxygen and ozone. Hence explain the difference in solubility between these two substances. **[3 marks]**

……

……

……

……

……

……

……

- **Compare the properties of the gaseous forms of oxygen and the oxygen free radical**

1. Explain why many properties of the gaseous forms of oxygen and the oxygen free radical cannot be compared. **[2 marks]**

....

....

....

....

2. Explain why the oxygen free radical is more reactive than gaseous forms of oxygen. **[2 marks]**

....

....

....

....

3. Identify ONE origin of oxygen free radicals. **[1 mark]**

....

4. Explain why the oxygen free radical is considered more toxic to humans than ozone. **[2 marks]**

....

....

....

....

- **Identify the origins of chlorofluorocarbons (CFCs) and halons in the atmosphere**

1. Identify the elements present in chloroflurocarbons. **[1 mark]**

....

....

2. Identify the elements present in halons. **[1 mark]**

....

....

3. Describe TWO uses of chloroflurocarbons. **[2 marks]**

……

……

……

……

4. Describe TWO uses of halons. **[2 marks]**

……

……

……

……

- **Identify and name examples of isomers (excluding geometrical and optical) of haloalkanes up to eight carbon atoms**

1. Construct structural formula for the following haloalkanes:
   a. 1,1,1,-trichloropropane **[1 mark]**

   b. 1,1,3,3,-tetraiodobutane **[1 mark]**

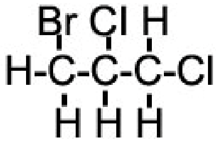
c. 4-chloroheptane **[1 mark]**

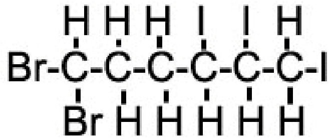
d. 1-chloro-2-fluoro-3,3-diiodoheptane **[1 mark]**

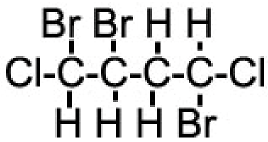
e. 2-bromo-3-chloropentane **[1 mark]**

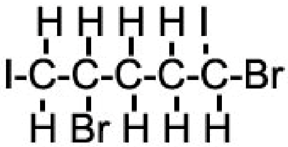
f. 1,1,3,3,-tetrabromobutane **[1 mark]**

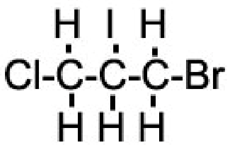
2. Name the following compounds: **[6 marks]**

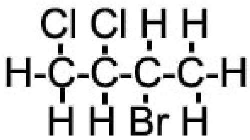
a) 

b) 

c) 

d) 

e) 

f) 

3. Everyday substances typically have different names to their typical names. Identify the systematic names of the following haloalkanes:
   a. Halothane: $CF_3CHClBr$ **[1 mark]**

………

   b. Halon: CF_2BrCl **[1 mark]**

………

   c. Methylene chloride: CH_2Cl_2 **[1 mark]**

………

d. Chloroform: $CHCl_3$ **[1 mark]**

……

4. Identify the number of isomers possible in 1,1,1-trichloropropane. **[1 mark]**

……

End of homework