Beatty Secondary School
Science Department (Chemistry Unit)
Chemistry 6092

Name: _____ ( ) Date: _____

Class: 4E1

TOPIC: AIR – ATMOSPHERE & ENVIRONMENT (WORKSHEET 2)

Learning Objectives:

(a) Discuss the importance of the ozone layer and the problems involved with the depletion of ozone by reaction with chlorine-containing compounds, chlorofluorocarbons (CFCs).

(b) Describe the carbon cycle in simple terms, to include
(i) the processes of combustion, respiration and photosynthesis,
(ii) how the carbon cycle regulates the amount of carbon dioxide in the atmosphere.

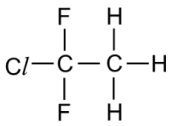
(c) State that carbon dioxide and methane are greenhouse gases and may contribute to global warming, give the sources of these gases and discuss the possible consequences of an increase in global warming.

Multiple-Choice Questions

1 Which statement about the ozone layer is true?

A It is a pollutant in the stratosphere.
B It absorbs some of the ultraviolet radiation from the Sun.
C Excess greenhouse gases can cause its depletion.
D It is destroyed when fluorine atoms react with the ozone molecules. (**B**)

2 In the past, CFC compounds were used as aerosol propellants. The structure of one CFC compound is shown.



Which element in this compound can cause the depletion of ozone?

A carbon **B** chlorine
C fluorine **D** hydrogen (**B**)

3 Which substance is the main cause of the greenhouse effect?

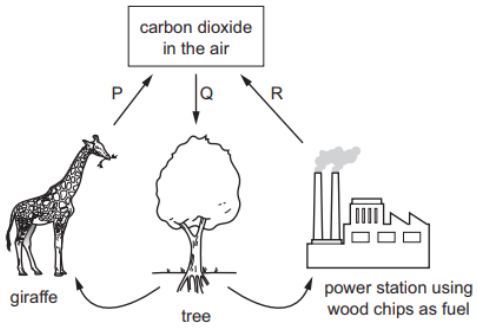
A carbon dioxide **B** chlorofluorocarbons (CFCs)
C ozone **D** sulfur dioxide (**A**)

4 The global atmospheric concentration of carbon dioxide has increased in the last 200 years. What could be causing this increase?

1 emissions from motor vehicles
2 photosynthesis
3 power stations using coal and oil

A 1 and 2 only **B** 1 and 3 only
C 2 and 3 only **D** 1, 2 and 3 (**B**)

5 The diagram shows part of the carbon cycle.



What are processes P, Q and R?

	P	Q	R
A	combustion	photosynthesis	respiration
B	photosynthesis	combustion	respiration
C	respiration	combustion	photosynthesis
D	respiration	photosynthesis	combustion

(**D**)

6 Which row shows both the correct source and the correct effect of the named pollutant?

	pollutant	source	effect
A	carbon monoxide	incomplete combustion of carbon-containing materials	global warming
B	oxides of nitrogen	decaying vegetable matter	global warming
C	ozone	photochemical reactions	acid rain
D	sulfur dioxide	volcanoes	acid rain

(**D**)

7 In what way do chloroflurocarbons, methane and nitrogen dioxide affect the atmosphere and the environment?

	chloroflurocarbons	methane	nitrogen dioxide
A	acid rain	depletion of the ozone layer	greenhouse gas
B	depletion of the ozone layer	acid rain	global warming
C	depletion of the ozone layer	greenhouse gas	acid rain
D	global warming	depletion of the ozone layer	acid rain

(**C**)

Structured Questions

8 The Mars atmosphere contains small amounts of methane. Scientists think this may be evidence of life. Methane on Earth is a pollutant gas.

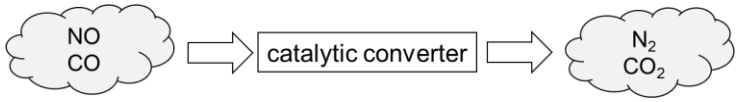
(a) What is the main source of methane in the Earth's atmosphere?

Bacterial decay of plant / vegetative and animal matter

(b) What environmental problem does methane cause on Earth?

Methane contributes to global warming.

9 Cars have catalytic converters fitted to reduce problems caused by some of the exhaust gases. The diagram shows some of the gases that enter and leave a catalytic converter.



(a) When catalytic converters were first available, some advertisements claimed they 'solved all car pollution problems'. Explain why this is **not** true.

Cars also produce sulfur dioxide which is not removed by catalytic converters. Sulfur dioxide causes acid rain.

Carbon dioxide gas produced from the catalytic converter is a greenhouse gas which causes global warming.

(b) What **environmental problems** do carbon monoxide and nitrogen oxides cause?

Carbon monoxide combines with haemoglobin in the blood thereby preventing the transport of oxygen by the blood. This causes death of organisms.

Nitrogen oxides react with rainwater and oxygen to form acid rain, which corrodes limestone buildings.

10 Hydrogen is a fuel that may be used on a large scale in the future for cars. Ethanol, C_2H_5OH, can also be used as a car fuel. In some countries, it is produced from the sugars in sugar cane.
An environmentalist claims that ethanol as a fuel is 'carbon neutral' because using it does not add to the amount of carbon dioxide in the atmosphere. Explain why this is true.

The combustion of ethanol releases carbon dioxide into the air. Sugar canes take in the carbon dioxide from the air through the process of photosynthesis. Thus the carbon is removed from the atmosphere.

11 Nitrogen monoxide damages the ozone layer by reacting with ozone is two steps.

$$NO + O_3 \rightarrow NO_2 + O_2 \qquad \text{step 1}$$

$$NO_2 + O_3 \rightarrow NO + 2O_2 \qquad \text{step 2}$$

(a) Give one natural source of nitrogen oxides in the atmosphere.

lightning activity

(b) Use oxidation states to identify which element is oxidised in step 1.

element **nitrogen** change in oxidation state **+2 in NO to +4 in NO_2**

(c) One NO molecule can destroy thousands of ozone molecules. Use equations for step 1 and 2 to explain why.

Every one nitrogen monoxide molecule is able to break down two ozone molecules and regenerate another nitrogen monoxide molecule in the two step reaction.

The newly generated nitrogen monoxide molecule is able to take part in the reaction again. Hence, a continuous cycle of nitrogen monoxide molecules is being regenerated and this can destroy thousands of ozone molecules

12 Chlorofluorocarbons, commonly known as CFCs, damage the ozone layer in the presence of sunlight. This is illustrated by trichlorofluoromethane, CCl_3F, a component of CFC, in a three step reaction shown below.

$$CCl_3F \rightarrow CCl_2F + Cl \qquad \text{step 1}$$

$$Cl + O_3 \rightarrow ClO + O_2 \qquad \text{step 2}$$

$$ClO + O \rightarrow Cl + O_2 \qquad \text{step 3}$$

(a) The table below shows the bond energies for some of the bonds in CFCs.

bond	bond energy in kJ/mol
C–F	485
C–Cl	327

energy

Use the table to explain why the ozone layer contains many more chlorine atom than fluorine atoms.

Breaking a C-F bond (485 kJ/mol) requires more energy than breaking a C-Cl bond (327 kJ/mol).

When energy from sunlight is absorbed by CFCs molecules, the probability of breaking C-Cl bond is therefore higher, resulting in many more chlorine atoms than fluorine atoms.

(b) State one source of chlorofluorocarbons.

propellants in aerosols / coolant in refrigerators and air-conditioners

(c) Write a balanced chemical equation for the overall conversion from ozone to oxygen **without** reference to the three steps of equation.

$2O_3 \rightarrow 3O_2$

(d) Explain the importance of the ozone layer.

Ozone layer reduces / filters out / absorbs the amount of ultra-violet rays reaching the earth.

This reduces the chances of cataracts, skin cancer and genetic mutation in humans.

(e) Ozone is a pollutant at ground level because it produces photochemical smog which is harmful to health. State how photochemical smog is formed.

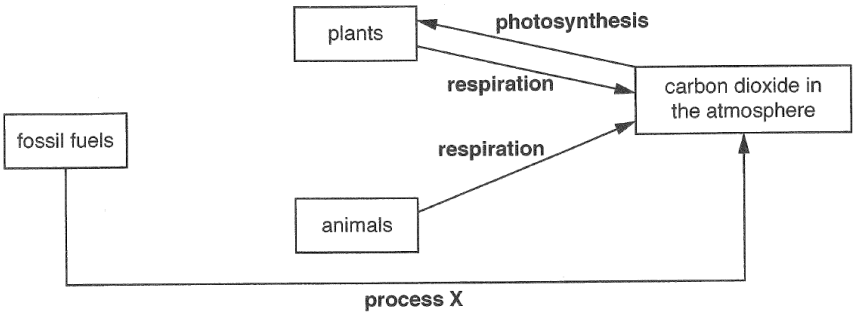
It is formed from the reaction of nitrogen oxides with unburnt hydrocarbons in the presence of sunlight.

(f) One CFC molecule containing CCl_3F can destroy thousands of ozone molecules. Use the equations to explain why.

One molecule of CCl_3F produces one Cl atom that can destroy one O_3 molecule. However, as shown in step 3, the Cl atom is regenerated.

Hence, the Cl atom can continue to react with another O_3 molecule as shown in step 2. Thus, there is a continuous cycle in which Cl atoms are used up and regenerated.

13 The diagram shows some of the processes that happen in the carbon cycle.



(a) Name **process X**. **complete combustion**

(b) (i) Write equations for the processes that happen during photosynthesis and respiration.

photosynthesis: **$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$**

respiration: **$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$**

(ii) Use your equations to explain how the processes of photosynthesis and respiration help to regulate the amount of carbon dioxide in the atmosphere.

During photosynthesis, plants absorbs carbon dioxide while during respiration, plants and animals releases carbon dioxide.

(c) The amount of carbon dioxide in the atmosphere is increasing due to our use of fossil fuels. One approach to this problem is to plant more trees. Suggest why planting more trees is **not** a long term solution to the increase in the amount of carbon dioxide.

The amount of carbon dioxide introduced into the atmosphere as a result of burning fossil fuels is much more than the amount that can be removed by photosynthesis.

Burning more fuels is a result of rapid industrialisation. Trees take a long time to mature, hence it is not a long term solution.

14 The table shows some information about Earth and some other planets. The predicted surface temperature of each planet takes into account a number of factors including its distance from the Sun. The prediction does not take into the account the absorption of heat by the atmosphere.

	Earth	Venus	Mercury
distance from Sun / millions of km	150	108	58
predicted surface temperature / °C	−18	−41	163
actual surface temperature / °C	15	462	167
composition of atmosphere	78% N_2 , 21% O_2, 0.04% CO_2 (plus other gases)	97% CO_2 (plus other gases)	none

(a) Use the information in the table to suggest reasons for the differences between the actual surface temperature and predicted surface temperature of each planet.

The predicted surface temperature (163°C) on Mercury is very closed to that of the actual surface temperature (167°C).
However, the predicted surface temperature of Earth and Venus are much lower than the actual due to the presence of CO_2 in the atmosphere which acts as a greenhouse gas to trap heat in the planet.

The difference between the predicted and actual temperature is much higher in Venus than on Earth as it has a much higher percentage (97 %) of CO_2 than Earth (0.04 %).

(b) Scientists think that the early atmosphere on Earth was similar to the atmosphere on Venus today. After plant life appeared, the atmosphere on Earth changed.

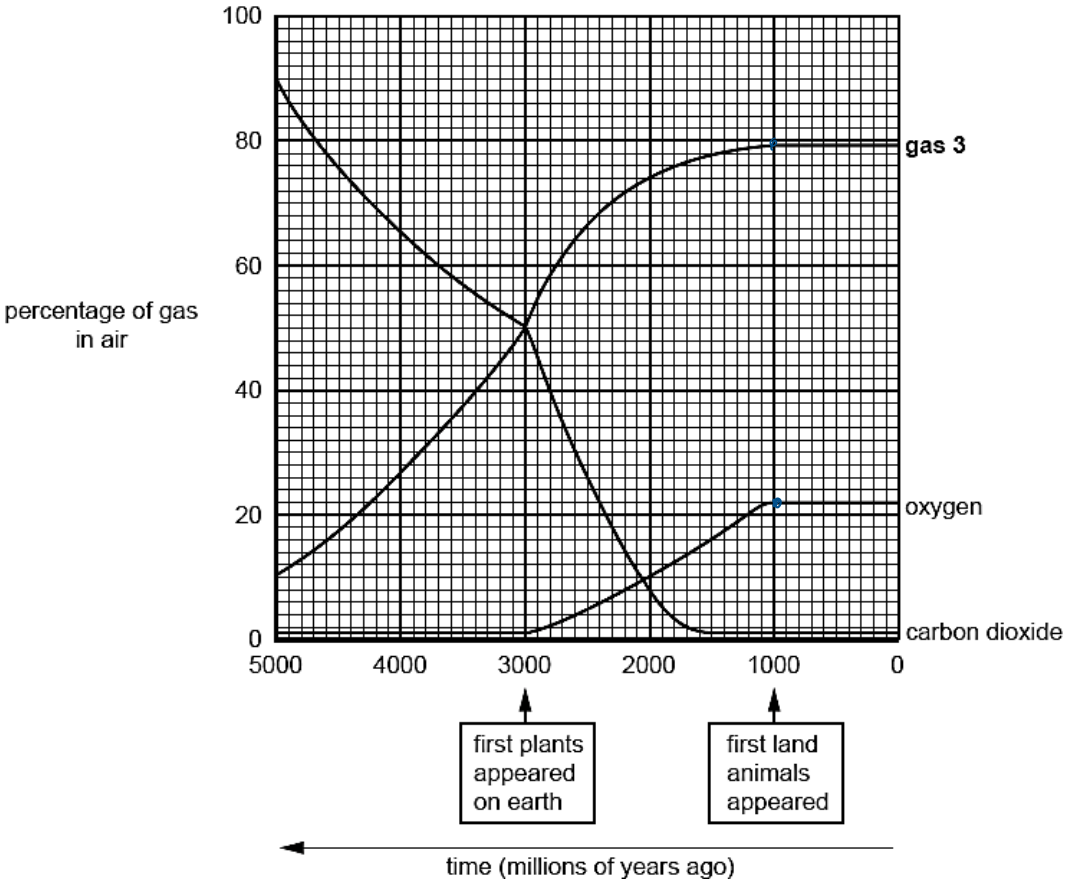
(i) Explain why plant life changed the percentages of oxygen and carbon dioxide on Earth.

Photosynthesis in plants requires sunlight and carbon dioxide. This process produces oxygen.
Hence reduces the percentage of CO_2 and increases the percentage of O_2 on Earth.

(ii) Explain, in terms of the processes involved, why the percentage of carbon dioxide on Earth is now increasing rapid.

Due to large scale deforestation which reduces the uptake of CO_2 by plants for photosynthesis and the burning of fossil fuels in the industry, the percentage of CO_2 on Earth is now increasing rapidly.

15 This graph shows how the percentage of three of the gases in the Earth's atmosphere has changed over five thousand million years.



Use the information from the graph to answer the following questions.

(a) (i) How long have the percentages of all gases in the atmosphere remained unchanged?

1000 million years

(ii) Name **gas 3**. Give a reason for your answer.

Gas 3 is nitrogen. It makes up 79% of the air in the atmosphere.

(b) (i) Describe how the percentages of carbon dioxide and oxygen have changed.

The percentage of carbon dioxide started falling 5000 millions of years ago. It then fell at a faster rate 3000 millions of years ago and then remained constant since 1500 millions of years ago until now.

The percentage of oxygen remained constant until 3000 million years ago when it started to increase. Then about 1000 millions years ago it remained constant until now.

(ii) Suggest an explanation for the changes that have taken place in carbon dioxide and oxygen percentages, identifying the processes involved and giving equations for any reactions.

The percentage of carbon dioxide in the air started dropping rapidly 3000 millions of years ago when the first plants appeared on earth. This is because plants use up carbon dioxide during photosynthesis. They produce oxygen in the process. Thus, the drop in the percentage of carbon dioxide is accompanied by an increase in the percentage of oxygen.

The equation to represent photosynthesis:
$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

About 1000 millions of years ago, the first land animals appeared on earth. Animals undergo respiration. They use up oxygen and produce carbon dioxide. This prevents the percentage of oxygen from increasing further and so, the percentage of oxygen becomes constant.

The equation to represent respiration:
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

Thus, both photosynthesis and respiration help to keep the percentage of carbon dioxide and oxygen in the atmosphere constant.

(c) (i) Explain why there has been a small but steady increase in atmospheric carbon dioxide over the past century from Year 1900 to 2000.

Due to the rapid increase in industrialisation from 1900 to 2000, there is an increase in the burning of fossil fuels in the industry, leading to an increase in the percentage of CO_2 on Earth.

(ii) Explain how excess carbon dioxide in the atmosphere can lead to global warming.

Carbon dioxide is a greenhouse gas and traps thermal energy. As such, excess carbon dioxide leads to a large amount of thermal energy being trapped and this leads to an increase in the average surface temperature, leading to global warming.