

## Topic 1: Elemental and Environmental

Total marks: 81

1. Selenium is an important nutrient, often added to fertilisers.

(a) Write the electronic configuration of Se, using subshell notation.

\_\_\_\_\_ (2)

(b) State the block of the periodic table in which Se is found.

\_\_\_\_\_ (1)

(c) State whether selenium has a low, intermediate or high electronegativity.

\_\_\_\_\_ (1)

(d)  $\text{SeO}_2$  reacts with NaOH to form  $\text{Na}_2\text{SeO}_3$ .

(i) Write an equation for this reaction.

\_\_\_\_\_ (2)

(ii) State the nature of the element selenium that is demonstrated by this reaction.

\_\_\_\_\_ (1)

(iii) The oxidation state of selenium in  $\text{SeO}_2$  and  $\text{SeO}_3^{2-}$  is +4.

Explain, by referring to the electronic configuration of selenium, how it is able to display an oxidation state of +4.

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\_\_\_\_\_ (2)

(iv) State one other positive oxidation state that selenium is likely to display in its compounds.

\_\_\_\_\_ (1)

2. Arsenic, which is toxic, can be found in dangerously high levels in some soils. This arsenic can be treated by causing it to attract to iron (III) oxides which are added to the groundwater.

(a) Write the electronic configuration of the  $\text{Fe}^{3+}$  ion, using subshell notation.

\_\_\_\_\_ (2)

(b) Arsenic in groundwater is initially in the form of arsenic (III) oxide, but reacts with the water to form arsenous acid,  $\text{H}_3\text{AsO}_3$ .

Write an equation for this reaction.

\_\_\_\_\_ (2)

(c) The uncharged arsenous acid in the soil water is converted to  $\text{H}_2\text{AsO}_4^-$  and  $\text{HAsO}_4^{2-}$  so that it will be attracted to the  $\text{Fe}^{3+}$  to be removed from the water.

State and explain whether  $\text{H}_2\text{AsO}_4^-$  or  $\text{HAsO}_4^{2-}$  will be more effectively removed from the water.

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\_\_\_\_\_  
\_\_\_\_\_ (2)

(d) Another element commonly found in soils is chromium, found naturally as  $\text{Cr}_2\text{O}_3$ .

$\text{Cr}_2\text{O}_3$  reacts with both  $\text{H}^+_{(\text{aq})}$  and  $\text{OH}^-_{(\text{aq})}$  in soils to form soluble ions.

State the name given to oxides that react with both  $\text{H}^+_{(\text{aq})}$  and  $\text{OH}^-_{(\text{aq})}$ .

\_\_\_\_\_ (1)

3. During industrial production of metals, large amounts of  $\text{SO}_2$  can be produced.

(a) The release of  $\text{SO}_2$  into the atmosphere may lead to the formation of acid rain.

Describe, with the aid of two equations, how the release of  $\text{SO}_2$  into the atmosphere lowers the pH of rain water.

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(4)

(b) Carbon dioxide in the atmosphere can also lower the pH of rain water.

Explain why carbon dioxide in the atmosphere is unlikely to lead to the formation of acid rain.

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(2)

(c) Describe one harmful environmental effect of acid rain.

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(2)

(d) It is unusual for rain water in Adelaide to reach a pH lower than 4.5.

Calculate the concentration, in  $\text{mol L}^{-1}$ , of  $\text{H}^+$  in rain water with a pH of 4.5.

(2)

4. Over the last century there has been a considerable increase in the use of titanium. The main source of titanium is in the mineral rutile,  $\text{TiO}_2$ .

(a) Explain why  $\text{TiO}_2$  is a solid with a high melting point.

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(2)

(b) If unused  $\text{TiO}_2$  is allowed to settle in a reservoir, it will react with water to produce hydroxide ions,  $\text{OH}^-$ .

Write an equation for this reaction.

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(2)

(c) In one reservoir the concentration of  $\text{OH}^-$  was measured to be  $3.2 \times 10^{-6} \text{ mol L}^{-1}$ .

Calculate the pH of the reservoir.

(3)

(d) In the production of titanium,  $\text{TiO}_2$  is treated to form titanium tetrachloride,  $\text{TiCl}_4$ .

(i) Carbon tetrachloride,  $\text{CCl}_4$ , is also produced in this reaction.

Draw a diagram to show the bonding and shape of the  $\text{CCl}_4$  molecule.

(2)

(ii) State the shape of the  $\text{CCl}_4$  molecule.

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(1)

5. The concentration of greenhouse gases in the Earth's atmosphere is increasing.

(a) Explain how an increase in the concentration of greenhouse gases may lead to an increase in the average temperature of the Earth's atmosphere.

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(3)

(b) State the name of this effect.

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(1)

(c) Describe one undesirable consequence that this increase in average temperature is predicted to have for the human population.

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(2)

(d) Increasing concentration of atmospheric CO<sub>2</sub> has been associated with global warming.

CO<sub>2</sub> molecules are non-polar even though they contain polar bonds.

(i) Explain why the bonds in CO<sub>2</sub> are polar.

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(2)

(ii) Explain why CO<sub>2</sub> molecules are non-polar.

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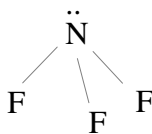
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(2)

6.  $\text{NF}_3$  is a potent greenhouse gas. The amount of  $\text{NF}_3$  in the atmosphere is increasing as a result of its increasing use in the electronics industry.

The diagram below shows the bonding and shape of a molecule of  $\text{NF}_3$ .



- (a) State why  $\text{NF}_3$  is a greenhouse gas.

\_\_\_\_\_ (1)

- (b) On the diagram above, show the polarity of an N–F bond in the  $\text{NF}_3$  molecule.

(1)

- (c) Explain why the  $\text{NF}_3$  molecule has trigonal pyramidal shape.

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\_\_\_\_\_  
\_\_\_\_\_ (2)

- (d) State the oxidation number of N in the  $\text{NF}_3$  molecule.

\_\_\_\_\_ (1)

- (e) Name the bonds that occur between N and F in a molecule of  $\text{NF}_3$ .

\_\_\_\_\_ (1)

- (f) Compare the strength of these bonds with the strength of the interactions between molecules of  $\text{NF}_3$ .

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\_\_\_\_\_  
\_\_\_\_\_ (2)

7. Proteins are molecules formed in plants such as sugar cane. To do this, sugar cane needs nitrogen.

(a) Explain why  $N_2$  cannot be used by plants as a source of nitrogen.

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(2)

(b) Nitrates can provide nitrogen in a form available to plants. Describe, with the aid of an equation, how nitrogen oxides in the atmosphere can lead to nitrates entering the soil for plants to use.

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(2)

(c) Some plants release  $H_2S$  during decomposition.

State whether  $H_2S$  is more likely to have come from an aerobic environment or an anaerobic environment.

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(1)

(d) State one product of aerobic decomposition of plants containing phosphorus.

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(1)

(e) Another molecule formed in sugar cane is glucose ( $C_6H_{12}O_6$ ).

(i) Name the reaction in which glucose is made from carbon dioxide and water.

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(1)

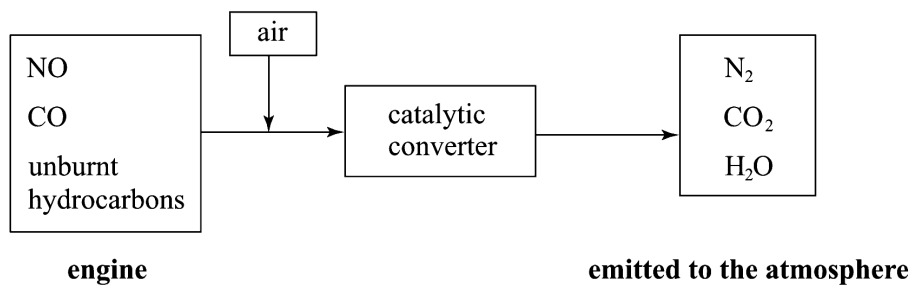
(ii) Write a balanced equation for this reaction.

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(2)

8. Catalytic converters reduce the amount of pollutants emitted from motor vehicles that use carbon-based fuels.

The diagram below shows the action of a catalytic converter in a motor vehicle:



- (a) Complete the following equation for one reaction that occurs in the catalytic converter.



(2)

- (b) Explain how NO is produced in the engines of motor vehicles.

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(2)

- (c) Explain how increased amounts of NO released into the atmosphere could lead to an increase in the concentration of tropospheric ozone.

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(2)

- (d) Both NO and ozone are pollutants that contribute to photochemical smog.

- (i) State whether ozone produced this way is a primary or secondary pollutant.

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(1)

- (ii) State one other component of photochemical smog.

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(1)



9. Water quality can be improved by adding aluminium ions and calcium hypochlorite to water.

(a) Describe how  $\text{Al}^{3+}$  removes suspended matter from water.

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(3)

(b) State the effect that the addition of  $\text{Al}^{3+}$  has on the appearance of the water.

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(1)

(c) In some regions  $\text{Al}^{3+}$  is naturally added to the soil water when acidic water reacts with  $\text{Al}_2\text{O}_3$  in the soil.

Write an equation for this reaction.

(2)

(d) Calcium hypochlorite added to swimming water produces  $\text{HClO}$ .

Explain how  $\text{HClO}$  makes water more suitable for swimming in.

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(2)

(e) The label on one container of calcium hypochlorite had the following information:

<b>Calcium hypochlorite</b> Harmful if swallowed. Contact with acids liberates toxic gas. Causes burns. Risk of serious damage to eyes.
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In addition to the use of protective clothing and glasses, other precautions must be taken to ensure safety when using calcium hypochlorite in a laboratory.

State one such precaution.

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(1)

**Topic 1: Elemental and Environmental****Marking Scheme**

Specific features		Grade	Comments
I3	<i>Manipulation of apparatus and technological tools Use of safe and ethical investigation procedures</i>		
AE1	<i>Analysis of data and concepts and their connections</i>		
A2	<i>Use of appropriate chemistry terms, conventions, formulae, and equations</i>		
KU1	<i>Demonstration of knowledge and understanding of chemistry concepts</i>		
KU2	<i>Use of knowledge of chemistry to understand and explain social or environmental issues</i>		