Chemistry Assessment

Task 3

Term 2 2014

Theory

Theory and Research

General Instructions

- **Reading time –** 2.5 minutes
- **Working time** – 55 minutes

- **Write using black or blue pen**
- **Write your Student Number at the top of pages 7 and 8.**
- **Board-approved calculators may be used**

- **A data sheet and a periodic table are provided.**

Total Marks – 38

Part A – 10 marks

- Attempt Questions (1-10)
- Allow about 10 minutes for this part

Part B – 28 marks

- Attempt Questions (11 – 18)
- Allow about 45 minutes for this part

Part A: Multiple Choice: 10 marks
Attempt Questions (1-10)
Allow about 10 minutes for this part
Use the answer grid on page 7

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

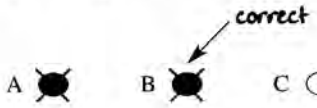
Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ⊗ C ○ D ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow as follows.



A ⊗ B ⊗ C ○ D ○

Multiple Choice
Mark your answer on the answer grid on page 7

1. What factor contributes to the layered structure of the Earth's atmosphere?

(A) difference in temperature

(B) difference in pressure

(C) difference in density of component gases

(D) inertia due to the rotation of the Earth

2. Which of the following gives a correct source of the given atmospheric pollutant?

	Pollutant	*Source*
(A)	ozone	diffusion from the stratosphere
(B)	carbon monoxide	incomplete combustion of fuels
(C)	sulfur dioxide	lightning strikes
(D)	nitrous oxide	dental clinics

Use this information to answer questions 3 and 4

Nitrogen dioxide is a brown gas which is manufactured from colourless nitric oxide by the following reaction:

$$2NO\,(g) + O_2\,(g) \rightleftharpoons 2NO_2\,(g) \qquad \Delta H = -5.66 \text{ kJ mol}^{-1}$$

The equilibrium constant for this reaction at 298 K is 0.74.

3. Which condition will cause the equilibrium constant, *K* to increase?

(A) increase the concentration of nitric oxide

(B) increase the temperature

(C) decrease the concentration of nitric oxide

(D) decrease the temperature

4. Which change will cause the reaction vessel to become more brown?

(A) increase the concentration of nitric oxide

(B) increase the temperature

(C) decrease the pressure

(D) decrease the concentration of nitric oxide

5. Which statement is correct in the use of atomic absorption spectroscopy to analyse a sample of water?

(A) The amount of light absorbed depends on the concentration of the metal ion in the sample.

(B) The amount of light absorbed depends on the concentration of the nonmetal ion in the sample.

(C) The amount of light transmitted is independent of the concentration of the metal ion in the sample.

(D) The amount of light transmitted is independent of the concentration of the nonmetal ion in the sample.

6. What is the main reason for the poor accuracy in the analysis of sulfate in fertilizer?

(A) The precipitate is partially soluble.

(B) The precipitate consists of very fine particles.

(C) The precipitate forms clumps with trapped impurities.

(D) The precipitate absorbs water from the atmosphere very quickly.

7. A student researching the industrial production of sodium hydroxide wrote the following statements:

(i) Molten sodium metal is produced at the anode of the mercury cell.
(ii) Sodium hydroxide solution is produced at the cathode of the membrane cell.
(iii) Chloride is oxidized at the cathode of the diaphragm cell.
(iv) Oxygen gas is produced at the cathode of the mercury cell.

Which of the statement is/are correct?

(A) (i) and (ii) only

(B) (iii) and (iv) only

(C) (ii) only

(D) (iv) only

8. What does the equipment shown in the photograph measure?

(A) dissolved material in the water

(B) light penetration of the water in a lake or pond

(C) flow of a stream or river

(D) depth of silt on the bottom of a lake

9. A group of students suggested the following conditions for the manufacture of sulfuric acid by the *Contact process:*

(i) 250 atm pressure
(ii) 100 kPa pressure
(iii) 100 atm pressure
(iv) 500 - 400 ^{o}C operating temperatures
(v) 25 ^{o}C operating temperature
(vi) a large excess of oxygen
(vii) a small excess of oxygen

Which of the suggested conditions are correct?

(A) (i), (iv) and (vi) only
(B) (ii), (v) and (vii) only
(C) (ii), (iv) and (vii) only
(D) (iii), (v) and (vi) only

10. In which reaction is sulfuric acid acting as an oxidant?

(i) $Cu(s) + H_2SO_4(l) \longrightarrow Cu^{2+}(aq) + SO_4^{2-}(aq) + SO_2(g) + 2H_2O(l)$

(ii) $C_{12}H_{22}O_{11}(s) + 11H_2SO_4(l) \longrightarrow 12C(s) + 11H_3O^+(aq) + 11SO_4^{2-}(aq)$

(iii) $Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$

(A) (i), (ii) and (iii)

(B) (i) and (iii) only

(C) (i) and (ii) only

(D) (ii) and (iii) only

Student Number ……

Part A . Answer grid for multiple choice questions

1.	A O	B O	C O	D O
2.	A O	B O	C O	D O
3.	A O	B O	C O	D O
4.	A O	B O	C O	D O
5.	A O	B O	C O	D O
6.	A O	B O	C O	D O
7.	A O	B O	C O	D O
8.	A O	B O	C O	D O
9.	A O	B O	C O	D O
10.	A O	B O	C O	D O

Total: ……../10

Student Number ……

Part B
Attempt Questions 11 – 18
Allow about 45 minutes for this part **Marks**

- ***Show all relevant working in questions involving calculations***

Question 11 (6 marks)

Account for ONE physical and ONE chemical property of ozone and oxygen by comparing their molecular structure and chemical bonding. Use diagrams and equations to support your answer. **6**

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Marks

Question 12 (2 marks)

Use Lewis electron dot structures in a chemical equation to illustrate the formation of a coordinate covalent bond. **2**

Question 13 (3 marks)

The depletion of the ozone layer was first reported in the late 1970s.

Give a series of equations to show the destruction of ozone in the stratosphere. **3**

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Test continues on the next page..

Marks

Question 14 (5 marks)

A sample of water from a domestic pipeline was measured for the presence of copper(II) ions. A calibration curve for absorbance of copper (II) ions was constructed using standard solutions containing copper(II) ions followed by the measured absorbance of an unknown sample from the pipeline.

The calibration curve showed that a solution with a concentration of 10 ppm had an absorbance of 0.400. The unknown solution had an absorbance of 0.500.

100 mL of the unknown solution was reacted with excess sodium carbonate solution. The precipitate formed was then weighed and dried.

Calculate the mass of the precipitate. Show all working. **5**

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Question 15 (2 marks)

Draw and label a diagram showing the technique of atomic absorption spectroscopy. **2**

Question 16 (4 marks)

Biochemical oxygen demand (BOD) is one criterion that can be used in evaluating the quality of water supply.

(a) Identify the characteristic of the water that this test assesses. **1**

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(b) How does the test for BOD relate to the characteristic indicated in (a)? **1**

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(c) Briefly describe how the BOD test is conducted. **2**

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Question 17 (4 marks)

Hydrogen gas and carbon monoxide gas react in the following equilibrium:

$$2H_2\,(g) + CO\,(g) \rightleftharpoons CH_3OH\,(g)$$

1.0 mol of H_2 and 1.0 mol of CO were placed in a 5.0 L container. When the system had reached equilibrium it was found that 0.20 mol CH_3OH had been formed.

Calculate the equilibrium constant for this reaction. **4**

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Question 18 (2 marks)

Outline two industrial uses of sulfuric acid. **2**

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End of Theory Test

Chemistry Assessment

Task 3

Term 2 2014

Theory

Research and Theory

Answers

General Instructions

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- **Working time** – 55 minutes

- **Write using black or blue pen**
- **Write your Student Number at the top of pages**

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- **A data sheet and a periodic table are provided at the back of the paper.**

Total Marks – 38

Part A – 10 marks

- Attempt Questions (1-10)
- Allow about 10 minutes for this part

Part B – 28 marks

- Attempt Questions (11-18)
- Allow about 45 minutes for this part

Part A: Multiple Choice: 7 marks
Attempt Questions (1-7)
Allow about 10 minutes for this part
Use the answer grid on page 5

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

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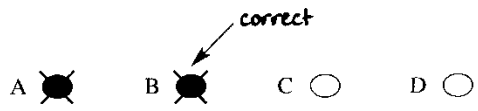

Multiple Choice
Mark your answer on the answer grid on page

1. What factor(s) contribute(s) to the layered structure of the Earth's atmosphere?

(**A) difference in temperature**

(B) difference in pressure

(C) difference in density of component gases

(D) inertia due to the rotation of the Earth

Outcome(s): H13

2. Which of the following gives a correct source of the given atmospheric pollutant?

	Pollutant	*Source*
(A)	ozone	diffusion from the stratosphere
(B)	**carbon monoxide**	**incomplete combustion of fuels**
(C)	sulfur dioxide	lightning strikes
(D)	nitrous oxide	dental clinics

Outcome(s): H13

Use this information to answer questions 3 and 4
Nitrogen dioxide is a brown gas which is manufactured from colourless nitric oxide by the following reaction.

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5. Which of the statements is correct in the use of atomic absorption spectroscopy to analyse a sample of water ?

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(C) The amount of light transmitted is independent of the concentration of the metal ion in the sample.

(D) The amount of light transmitted is independent of the concentration of the nonmetal ion in the sample.

Outcome(s): H3

6. What is the main reason for the poor accuracy in the analysis of sulfate in fertilizer?

(A) The precipitate is partially soluble.

(B) The precipitate forms very fine particles.

(C) The precipitate forms clumps with trapped impurities.

(D) The precipitate absorbs water from the atmosphere very quickly.

Outcome(s): H4

7. A student researching the industrial production of sodium hydroxide wrote the following statements.

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Which of the statement is/are correct?

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(B) (iii) and (iv) only

(C) (ii) only

(D) (iv) only

Outcome(s): H13

8. What does the equipment shown in the photograph measure?

(A) dissolved material in the water

(**B**) **light penetration of the water in a lake or pond**

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10. In which reaction is sulfuric acid acting as an oxidant?

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(iii) $Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$

(A) (i), (ii) and (iii)

(B) (i) and (iii) only

(C) (i) and (ii) only

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Student Number ……

Part A . Answer grid for multiple choice questions

1.	A ●	B O	C O	D O
2.	A O	B ●	C O	D O
3.	A O	B O	C O	D ●
4.	A ●	B O	C O	D O
5.	A ●	B O	C O	D O
6.	A O	B ●	C O	D O
7.	A O	B O	C ●	D O
8.	A O	B ●	C O	D O
9.	A O	B O	C ●	D O
10.	A O	B ●	C O	D O

Total: ……../10

Student Number ……

Part B
Attempt Questions 10- 16.
Allow about 45 minutes for this part **Marks**

- ***Show all relevant working in questions involving calculations***

Question 11 (6 marks)

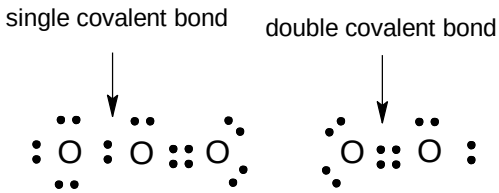
Account for ONE physical and ONE chemical property of ozone and oxygen by comparing their molecular structure and chemical bonding. Use diagrams and equations to support your answer. **6**

Sample answer:
Differences in the physical properties of ozone and oxygen results from difference in molecular structure:

Ozone has a higher boiling point compared with oxygen. The higher boiling point of ozone is due to the higher molar mass of ozone (48) compared with oxygen (32). The higher molar mass results in higher dispersion forces. Higher dispersion forces necessitates the application of greater amount of energy to overcome the intermolecular forces between molecules.

Difference in the bonding of ozone and oxygen results in a greater reactivity of ozone compared with oxygen.

The electron dot structures of ozone and oxygen are shown.:



The greater reactivity of ozone results from greater ease with which the single covalent bond in ozone breaks producing oxygen atom and oxygen molecule.

$$O_3 \rightarrow O + O_2;$$

In contrast, when oxygen reacts, a double needs to be broken.

$$O_2 \rightarrow O + O$$

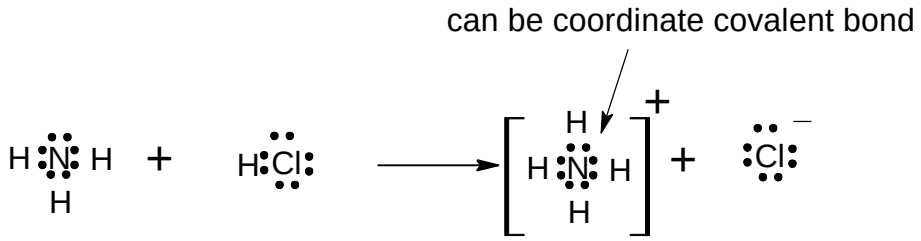
It is easier to break the single bond in ozone than it is to break the double bond in the oxygen molecule and hence ozone is more reactive than oxygen.

Criteria	*Marks*
Statement of the physical and molecular properties of ozone and oxygen	*2*
Attribution of the physical properties to molecular structure and a discussion how the difference is caused by molecular structure	*2*
Attribution of the chemical properties to bond strength in ozone and oxygen and a discussion why there is a difference in bond strength	*2*

Question 12 (2 marks)

Use Lewis electron dot structures in a chemical equation to illustrate the formation of a coordinate covalent bond.

Sample answer



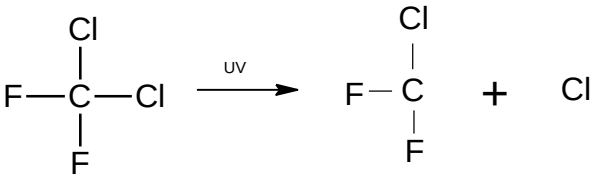
Criteria	*Marks*
Correct proton transfer reaction expressed with electron dot diagram	*2*
Correct proton transfer reaction with no electron dot diagram	*1*

Question 13 (3 marks)

The depletion of the ozone layer was first reported in the late 1970s.

Give a series of equations to show the destruction of ozone in the stratosphere

Sample answers:



$$Cl + O_3 \longrightarrow ClO + O_2$$

$$ClO + O \longrightarrow O_2 + Cl$$

Marking guidelines

Criteria	*Marks*
three correct equations	*3*
two correct equations	*2*
one correct equation	*1*

Question 14 (5 marks)

A sample of water from a domestic pipeline was measured for the presence of copper(II) ions.
A calibration curve for absorbance of copper (II) ions was constructed using standard solutions containing copper(II) ions followed by the measured absorbance of an unknown sample from the pipeline.

The calibration curve showed that a solution with a concentration of 10 ppm had an absorbance of 0.400.

The unknown solution had an absorbance of 0.500.

100 mL of the unknown solution was reacted with excess sodium carbonate solution.
The precipitate was then weighed and dried.

Calculate the mass of the precipitate formed. Show all working

Outcome(s): H3

Sample Answer :

Standard solution has 10 ppm copper (II) ions.

Thus, unknown sample has $\frac{0.500}{0.400} x 10 =$ *12.5 ppm = 0.0125 g/L*

Molar mass of copper (II) carbonate = 63.55 + 12.01 + (3 x 16.00) = 123.56 g

Molar mass of copper (II) ions = 63.55 g

Thus mass of copper (II) carbonate = $\frac{0.0125 \frac{g}{L} \; x \; 0.100L}{63.55}$ *x 123.56 = 2.43 x* 10^{-3} *g*

Marking criteria

Criteria	*Marks*
Correct answer showing all working	*5*
One error in calculations	*4*
Two errors in calculations	*3*
Three errors in calculations	*2*
Four errors in calculations	*1*

Question 15 (2 marks)

Draw and label a diagram showing the technique of atomic absorption spectroscopy.

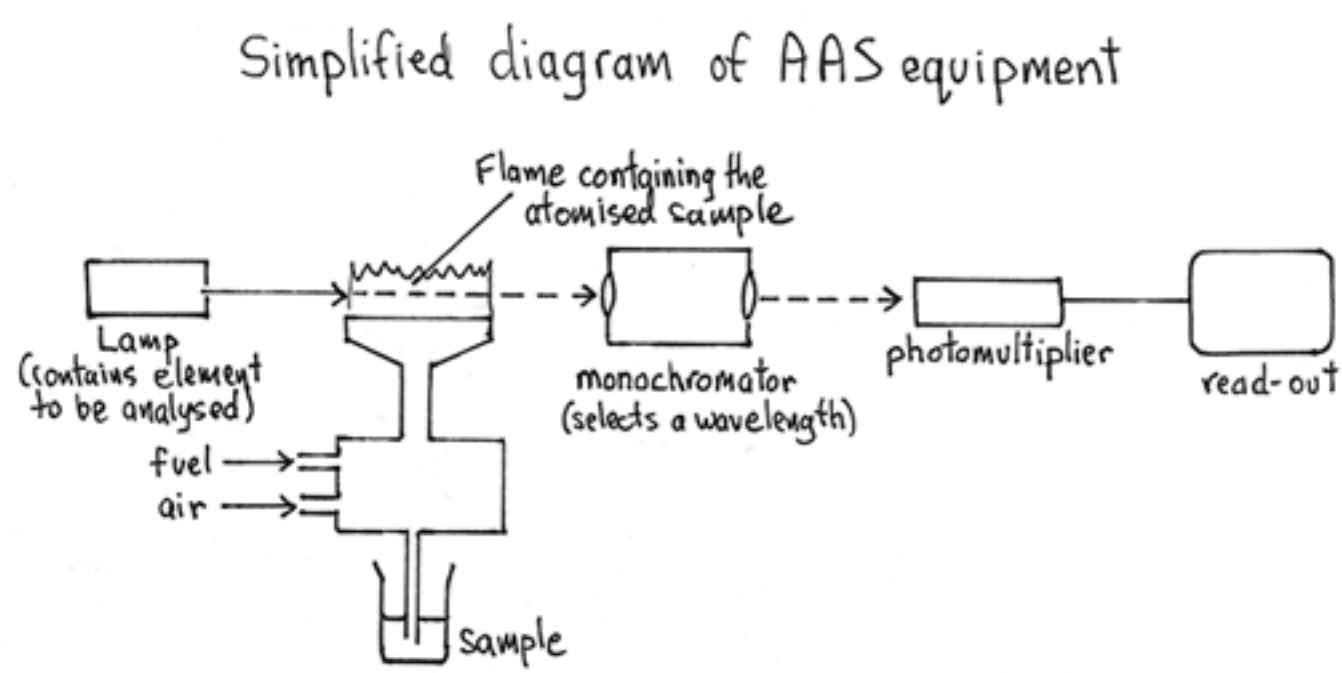


Diagram from NSW HSC Online: Charles Sturt University and the Department of Education and Communities, NSW

Outcome(s): H2

Sample Answer : diagram must include lamp, flame with aspirator and sample going into flame, detector, computer
Marking criteria

Criteria	*Marks*
Correct, neatly drawn and labelled diagram	*2*
Some components missing	*1*

Question 16 (4 marks)

Biochemical oxygen demand (BOD) is one criterion that can be used in evaluating the quality of water supply.

(a) Identify the characteristic of the water that this test assesses. **1**

Answer	**Marks Allocated**
Any answer that indicates that the student recognises that the characteristic is organic material that is present in the water	1 mark

Sample answer
It is a measure of the amount of biologically degradable organic material that is present in the water.

(b) How does the test for BOD relate to the characteristic indicated in (a)? **1**

Any answer that indicates a link between the breakdown of the organic material by microorganisms and their oxygen consumption.

Sample answer
It indicates the amount of oxygen that aerobic aquatic organisms could potentially consume in the process of metabolising all the organic matter available to them.

(c) Briefly describe how this test is conducted. (2 marks) **2**

Answer	**Marks Allocated**
Indicates that one sample is tested immediately for DO. ***AND*** *Indicates that second sample is tested after 5 days in the dark, the difference being the BOD*	*2 marks*
Indicates or implies that 2 samples must be taken. ***OR*** *Mentions that one sample must be stored for approx 5 days in the dark.*	*1 mark*

Sample Answer:
1. Two samples of the water being tested are taken
2. One sample is measured for DO as soon as possible while the other sample is kept in a dark place for 5 days and then tested for DO. The BOD is calculated by subtracting the DO value after 5 days from the initial DO value.

Question 17 (4 marks)

Hydrogen and carbon monoxide react as gases in the following equilibrium.

$$2H_2\,(g) + CO\,(g) \rightleftharpoons CH_3OH\,(g)$$

1.0 mol of H_2 and 1.0 mol of CO were placed in a 5 L container. When the system had reached equilibrium it was found that 0.20 mol CH_3OH had been formed. Calculate the equilibrium constant for this reaction.

Sample answer

$2H_2\,(g)$ + $CO\,(g)$ $\rightleftharpoons$ $CH_3OH\,(g)$

	H_2	CO	CH_3OH
Initial mol	*1.0*	*1.0*	*0.0*
Initial [ ] = mol/5	*0.2*	*0.2*	*0.0*
Change	*0.080*	*0.040*	
Final [ ]	*0.12*	*0.16*	*0.20/5 = 0.040*

$K = [CH_3OH\ ]\ /\ [H_2\ ]^2 x\ [\ CO\ ]$
$= 0.040\ /\ 0.12^{\ 2} x\ 0.16$
$= 17$

Marking Criteria	*Marks*
• Correct calculation with all relevant working and K expression	4
• Correct calculation with all relevant working	3
• Some relevant working	2
• K expression OR • One correct calculation	1

Outcome : H10

Question 18 (2marks)

Outline two industrial uses of sulfuric acid.

Outcome(s): H4

Sample Answer

Used to make superphosphate fertilizer by reacting rock phosphate with sulfuric acid to make the fertilizer soluble.

Oil refining where many impurities are removed from petroleum products by reacting with sulfuric acid.

Extraction of metals from ores where the oxide obtained after roasting is dissolved in sulfuric acid.

Criteria	Marks
Two correct outlines	*2*
One correct outline OR identifies two uses	*1*

End of Theory Test