# 2013

**TRIAL HSC EXAMINATION**

# Chemistry

## General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Write your Student Number at the top of pages 11 12, 14, 16, 18, 20 and 22.
- Board-approved calculators may be used
- A data sheet and a Periodic Table are provided at the back of this paper.

**Total Marks – 100**

**Section I** Pages 2 – 22

**75 marks**

This section has two parts, Part A and Part B

Part A – 20 marks
•Attempt Questions 1- 20
•Allow about 35 minutes for this part

Part B – 55 marks
•Attempt Questions 21 – 33
•Allow about 1 hour and 40 minutes for this part

**Section II** Page 23

**25 marks**

•Attempt Question 34
•Allow about 45 minutes for this section

## Section I
**75 marks**

**Part A – 20 marks**
**Attempt Questions 1-20**
**Allow about 35 minutes for this part**

Mark your answers on the ANSWER grid on page 11.

.

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

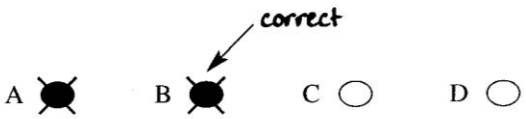
**Sample:** $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

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.




Mark your answers on the ANSWER grid on page 11.

**Multiple Choice**

Use the multiple – choice answer sheet for Questions 1 – 20 .

**1.** In the following nuclear reaction, what is the identity of $X$ ?

$$^{234}_{91}Pa \rightarrow {}^{234}_{92}U + X$$

(A) gamma radiation

(B) $^{4}_{2}He$

(C) $^{0}_{-1}e$

(D) $^{0}_{-1}H$

**2.** Which of the following is important in the nuclear stability of an atom ?

(A) the ratio of protons to electrons

(B) the ratio of protons to neutrons

(C) the atomic radius

(D) the atomic mass

**3.** A type of polymerisation reaction involves the release of a water molecule.
Which monomer is most likely to be involved in this reaction?

(A) ethane

(B) styrene

(C) glucose

(D) vinyl chloride

**4.** Expanded polystyrene can be produced by blowing gases through molten polystyrene and then allowing it to cool. A common use of this polystyrene is in the manufacture of protective foam packaging**.**

Which property of polystyrene makes it suitable for this use?

(A) stiffness

(B) transparency

(C) flexibility

(D) brittleness

**5.** Consider the following oxidation – reduction reaction:

$$I_2(aq) + 2\ S_2O_3^{2-}(aq) \rightarrow 2\ I^-(aq) + S_4O_6^{2-}(aq)$$

Which is the oxidant in the reaction?

(A) $I_2$

(B) $S_2O_3^{2-}$

(C) $I^-$

(D) $S_4O_6^{2-}$

**6.** Which list gives the species in the order of decreasing oxidising ability?

(A) $F_2$, $H^+$, $Ag^+$, $Cu^{2+}$

(B) $H_2O$, $Mg^{2+}$, $Al^{3+}$, $Mn^{2+}$

(C) $MnO_4^-$, $Br_2$, $Ni^{2+}$, $Al^{3+}$

(D) $Ca^{2+}$, $Mg^{2+}$, $Al^{3+}$, $Zn^{2+}$

**7.** Use the information to answer this question.

| *Indicator* | *Colour change* | *Transition pH* |
|---|---|---|
| Methyl orange | red to yellow | 3.1 – 4.4 |
| Bromothymol blue | yellow to blue | 6.2 – 7.6 |
| Phenolphthalein | colourless to pink | 8.3 – 10 |
| Litmus | red to blue | 5.1 – 8.0 |

If a few drops of the indicator are added separately to four flasks containing 0.00001 mol $L^{-1}$ HCl. What will be the colour of each solution containing the indicator?

| | *Methyl orange* | *Bromothymol Blue* | *Phenolphthalein* | *Litmus* |
|---|---|---|---|---|
| (A) | red | yellow | colourless | red |
| (B) | yellow | blue | colourless | blue |
| (C) | red | yellow | pink | red |
| (D) | yellow | yellow | colourless | red |

**8.** Given the following reactions of $SO_2$:

(i) $2\ SO_2(g) + O_2(g) \rightleftharpoons 2\ SO_3(g)$

(ii) $SO_2\ (g) + 2\ H_2O\ (l) \rightleftharpoons HSO_3^-\ (aq) + H_3O^+(aq)$

(iii) $SO_2\ (g) + CaO\ (s) \rightleftharpoons CaSO_3(s)$

Which reactions show the acidic nature of sulfur dioxide?

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

(B) (i) and (ii) only

(C) (i) and (iii) only

(D) (ii) and (iii) only

**9.** Airbags are safety features of modern cars that are designed to reduce the impact on passengers by rapid inflation in the event of a collision.

The main reaction is given by the following equation:

$$2NaN_3\ (s) \rightarrow 2Na\ (s) + 3N_2\ (g)$$

The sodium generated is eliminated in a subsequent reaction.

What mass of solid sodium azide ($NaN_3$) is theoretically required to inflate a 60.00 litre airbag with the volume being measured at 25 $^oC$ and 100 kPa?

(A) 105 g

(B) 236 g

(C) 53.0 g

(D) 118 g

**10.** Consider the following pairs of substances:

(i) $PO_4^{3-}$ and $H_2PO_4^-$

(ii) $O^{2-}$ and $OH^-$

(iii) $SO_3^{2-}$ and $H_2SO_3$

(iv) $NH_3$ and $NH_2^-$

Which are conjugate acid-base pair(s)?

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

(B) (i) and (iii) only

(C) (ii) and (iv) only

(D) (ii), (iii) and (iv) only

**11.** What is the pH of a mixture of 20.0 mL of 0.102 mol $L^{-1}$ barium hydroxide solution and 40.0 mL of 0.150 mol $L^{-1}$ hydrochloric acid diluted to a final volume of 100 mL?

(A) 2.715

(B) 1.717

(C) 11.285

(D) 12.284

**12.** Understanding the effect of trace elements on the health and well-being of plants and humans requires the use of instruments with certain characteristics.
What is the most important of these characteristics?

(A) The instrument can detect low concentrations of the element.

(B) The instrument is selective to the element even in the presence of impurities.

(C) The instrument is easy and quick to operate.

(D) The instrument can easily be automated.

**13.** A student needed to compare the strength of the three hypothetical acids $H_2A$, HB and HC .
The following suggestions were given by other students.

(i) Prepare 0.100 mol $L^{-1}$ solutions of each of $H_2A$, HB and HC and then titrate with 0.100 mol L NaOH solution.

(ii) Prepare 0.100 mol $L^{-1}$ solutions of each of $H_2A$, HB and HC and then measure the pH of each one with a pH meter.

(iii) Prepare a 0.0500 mol $L^{-1}$ $H_2A$, 0.100 mol $L^{-1}$ HB and 0.100 mol $L^{-1}$ HC and then titrate with 0.100 mol L NaOH solution.

(iv) Prepare a 0.0500 mol $L^{-1}$ $H_2A$, 0.100 mol $L^{-1}$ HB and HC and then measure the pH of each one with a pH meter.

Which of the suggestions should the student follow?

(A) (i)

(B) (ii)

(C) (iii)

(D) (iv)

**14.** While actually doing the experiment to compare the dissolved oxygen in several water samples, which controlled variable is the most important?

(A) The size of the bottle used to contain the samples should be the same.

(B) The intensity of light during the experiment should be different for all samples.

(C) The analysis time for each sample should be the same.

(D) The temperature of the samples should all be the same.

**15.** A student used the evaporation technique to determine the total dissolved solids in a water sample provided by her teacher.

She obtained the following results:

| | *Mass (g)* |
|---|---|
| Mass of empty evaporating basin | 300.00 |
| Mass of filter paper | 20.45 |
| Mass of evaporating basin + water sample | 1300.00 |
| Mass of filter paper + residue | 20.73 |
| Mass of evaporating basin + residue | 300.86 |

Which of the following are the correct results of the experiment?

| | *Total suspended solids (ppm)* | *Total dissolved solids (ppm)* |
|---|---|---|
| (A) | 280 | 860 |
| (B) | 860 | 280 |
| (C) | 0.28 | 0.86 |
| (D) | 0.86 | 0.28 |

**16**. Which would be an appropriate test to monitor the chemicals that may lead to eutrophication in waterways ?

(A) add barium chloride solution

(B) add ammonium molybdate solution

(C) add nitric acid

(D) add sodium hydroxide solution

**17.** Which is a correct sequence to purify and sanitise mass water supplies?

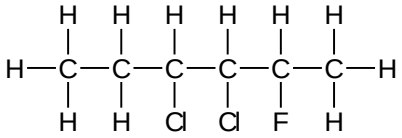
(A) add $Fe^{3+}$ → filter → add NaOH → add $Cl_2$

(B) add NaOH → add $Fe^{3+}$ → filter → add $Cl_2$

(C) filter → add NaOH → add $Fe^{3+}$ → add $Cl_2$

(D) add NaOH → add $Fe^{3+}$ → add $Cl_2$

**18.** What is the IUPAC name of the following compound?



(A) 5-fluoro-3,4-dichlorohexane

(B) 2-fluoro-3,4-dichlorohexane

(C) 3,4-dichloro-5-fluorohexane

(D) 3,4-dichloro-2-fluorohexane

**19.** Which of the following would most affect the concentration of ions in lakes?

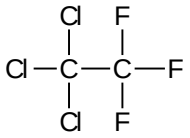
(A) the amount of rainfall

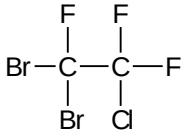
(B) the proximity to rubbish dumps

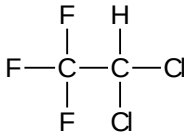
(C) the pathway of rain to the waterbody

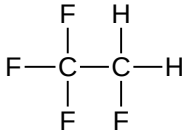
(D) the amount of human activity near the waterbody

**20**. Which compound has the highest ozone-depleting potential?

(A) 

(B) 

(C) 

(D) 

**Student Number** …….

**Section I** **Mark -----/20**

**Part A**

**Multiple Choice Answer Sheet**

---

| | | | | |
|---|---|---|---|---|
| **1**. | A ○ | B○ | C ○ | D ○ |
| **2**. | A ○ | B ○ | C ○ | D ○ |
| **3**. | A ○ | B ○ | C ○ | D ○ |
| **4**. | A ○ | B ○ | C ○ | D ○ |
| **5**. | A ○ | B ○ | C ○ | D ○ |
| **6**. | A ○ | B ○ | C ○ | D ○ |
| **7**. | A ○ | B ○ | C ○ | D ○ |
| **8**. | A ○ | B ○ | C ○ | D ○ |
| **9**. | A ○ | B ○ | C ○ | D ○ |
| **10**. | A ○ | B ○ | C ○ | D ○ |
| **11**. | A ○ | B ○ | C ○ | D ○ |
| **12**. | A ○ | B ○ | C ○ | D ○ |
| **13** | A ○ | B ○ | C ○ | D ○ |
| **14**. | A ○ | B ○ | C ○ | D ○ |
| **15**. | A ○ | B ○ | C ○ | D ○ |
| **16**. | A ○ | B ○ | C ○ | D ○ |
| **17**. | A ○ | B ○ | C ○ | D ○ |
| **18**. | A ○ | B ○ | C ○ | D ○ |
| **19**. | A ○ | B ○ | C ○ | D ○ |
| **20**. | A ○ | B ○ | C ○ | D ○ |

## Chemistry
## Section 1 (continued)

**Student Number ……..**

**Part B. 55 marks**
**Attempt questions 21 - 33**
**Allow about 1 hour and 40 minutes for this part**

- *Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.*
- *Show all relevant working in questions involving calculations.*

---

**Question 21**. (5 marks) **Marks**

Justify the development in technology from the *lead acid* or the *dry cell* to another battery with reference to their chemistry, cost and practicality. **5**

…….

……

……

……

……

……

……

……

……

……

……

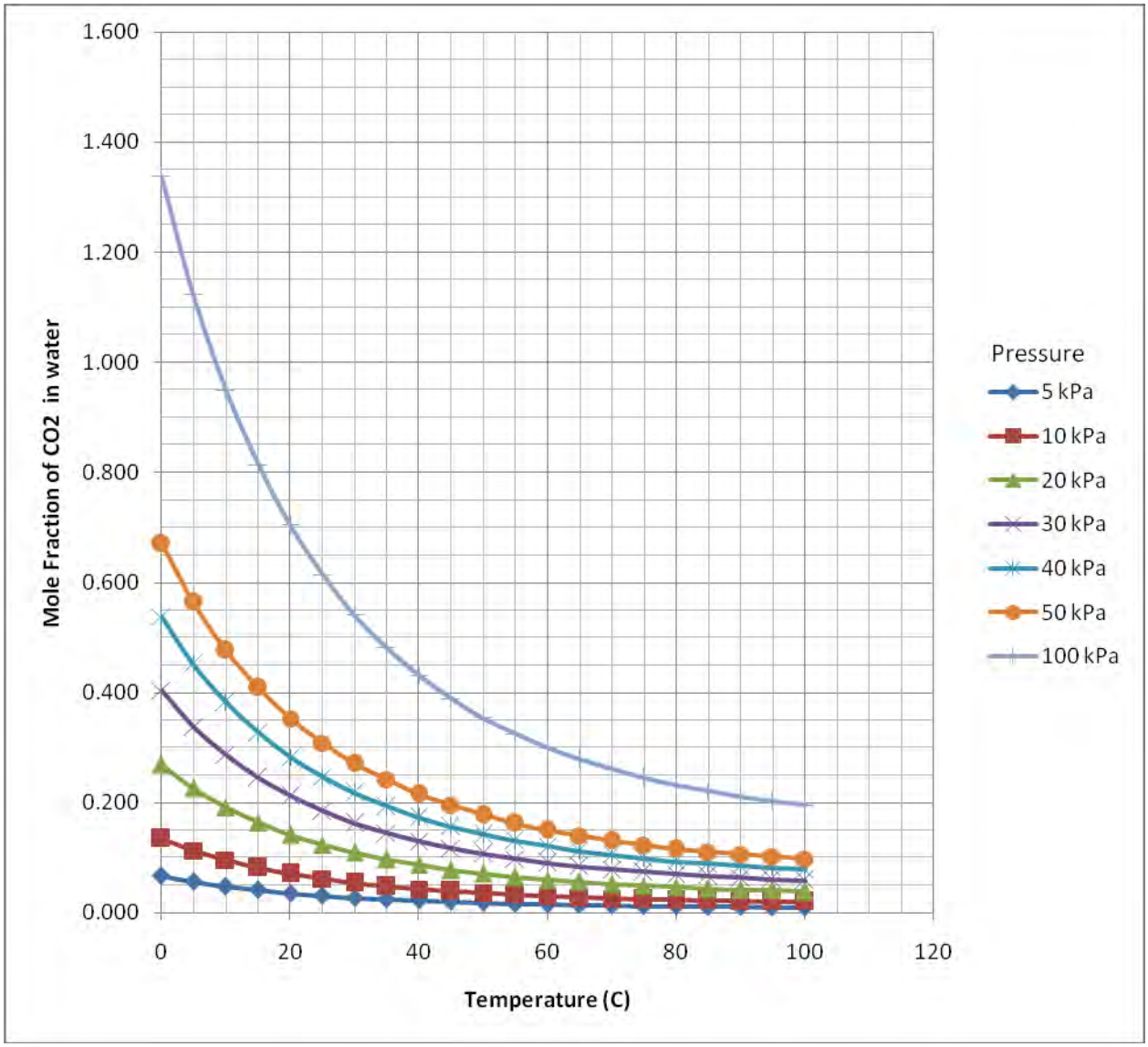
……

……

**Marks**

**Question 22** (8 marks)

Concentration can also be expressed in mole fraction. Mole fraction of a component is equal to the number of moles of the component over the total number of moles of the components of the mixture. Examine the graph of mole fraction of carbon dioxide (in a carbon dioxide - water mixture) against temperature at various pressures.




(a) Describe the variation of the solubility of carbon dioxide with temperature and with pressure. **2**

……

……

……

……

*Question 22 continues on the next page...*

**Marks**

(b) Justify the variation of the solubility of carbon dioxide with pressure at 20 $^{o}$C using a relevant equation and Le Chatelier's principle. **3**

……

……

……

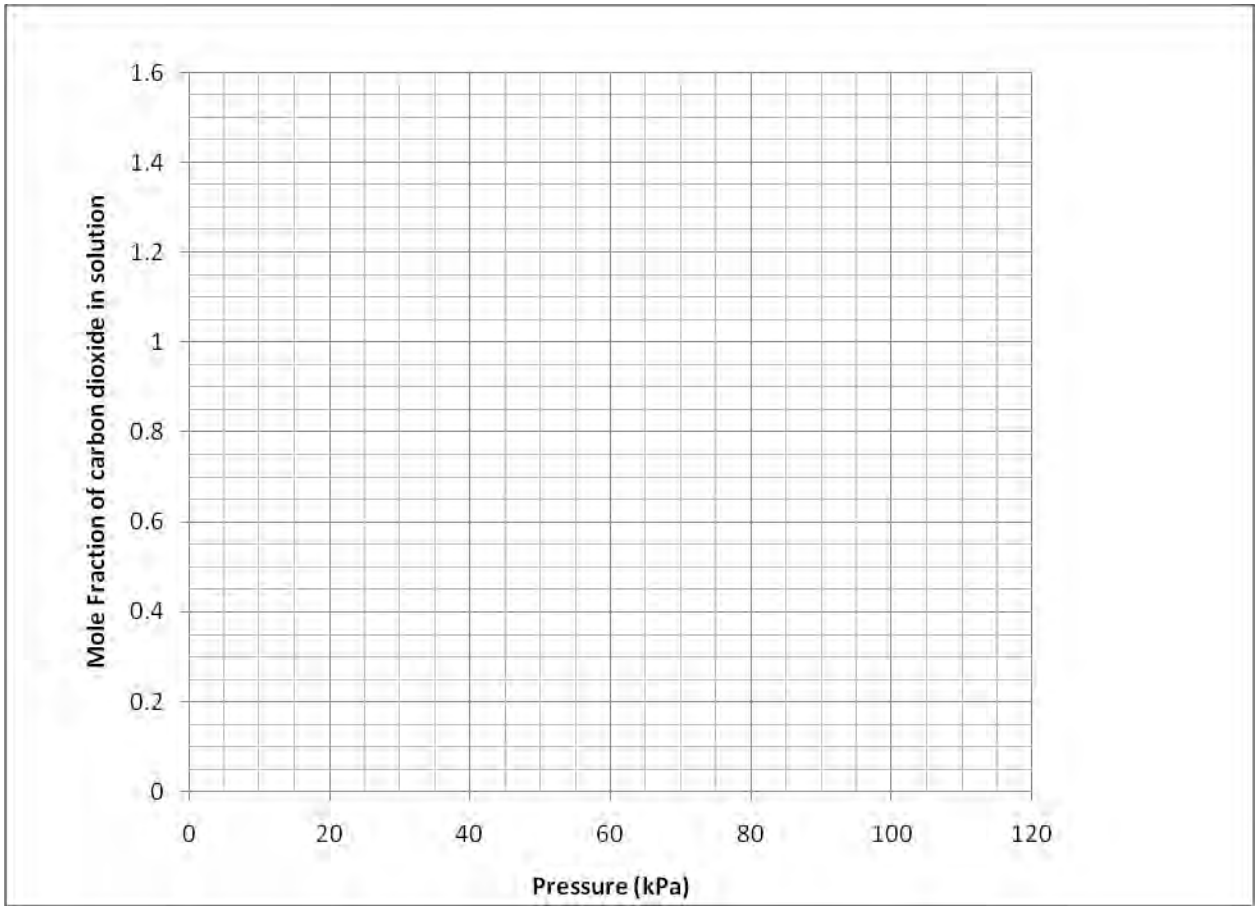
……

……

……

……

(c) Plot a graph of the mole fraction of carbon dioxide in solution versus pressure at a temperature of 0$^{o}$C. **2**




(d) Use the graph to determine the mole fraction of carbon dioxide in the solution at a pressure of 80 kPa. **1**

……

**Marks**

**Question 23** (2 marks)

Write balanced equations to show the ionisation in water of a weak acid HA and a strong acid HB. **2**

| | |
|---|---|
| HA | |
| HB | |

**Question 24** (4 marks)

Identify a conjugate acid-base pair which can be used as an effective buffer.

Discuss how this buffer can maintain the pH when a base is added to it **4**

…….

…….

…….

…….

……

……

……

**Question 25** (4 marks)

Describe the correct sequence of steps used in the first-hand investigation you performed in the laboratory to determine the concentration of vinegar by titration with standard sodium hydroxide solution. Include correct techniques and equipment which made this investigation valid. **4**

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

**Marks**

**Question 26** (5 marks)

A sample of lemon juice is to be analysed in the laboratory. A student took 25.00 mL of the juice and diluted it to 250.00 mL. Exactly 25.00 mL of the diluted lemon juice is titrated with standard 0.1045 mol $L^{-1}$ sodium hydroxide solution using phenolphthalein as the indicator. An average titre of 24.05 mL of sodium hydroxide was required

Assuming that the lemon juice contained only citric acid (molar mass = 192.1 g/mol), calculate the concentration in mol $L^{-1}$ of citric acid in the undiluted lemon juice. **5**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

……

……

……

……

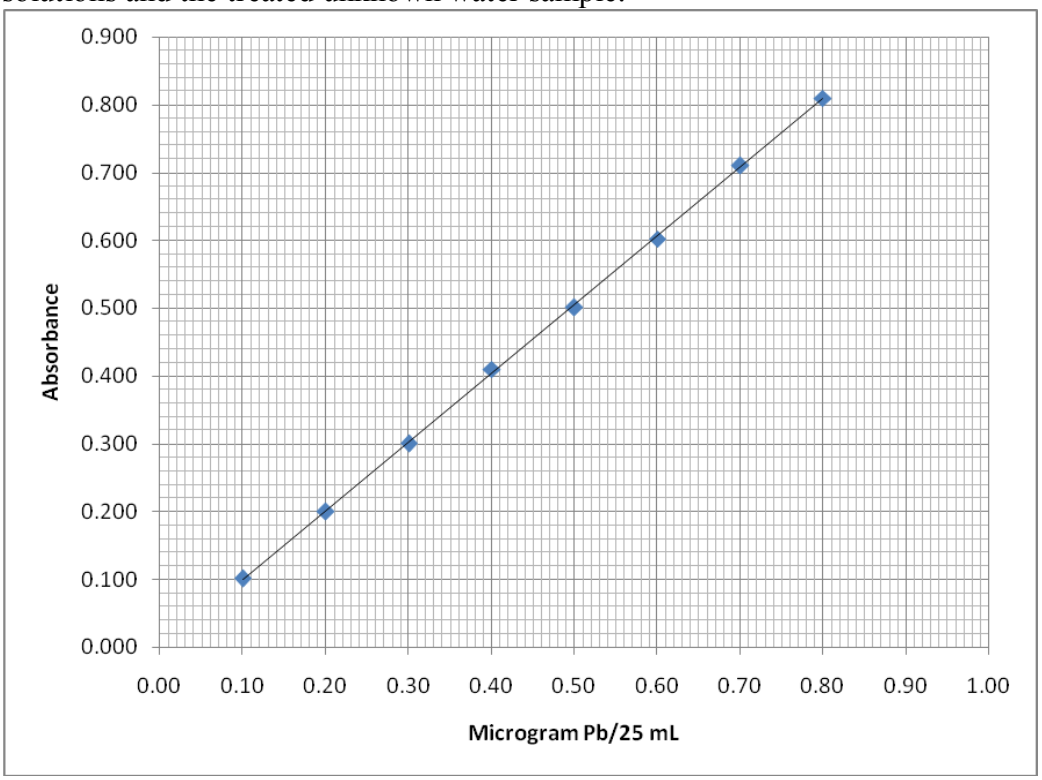
**Student Number** ……..

**Marks**

**Question 27** (3 marks)

The lead ion precipitates with phosphate to form lead phosphate. An excess of a solution of sodium phosphate was added to exactly 100.00 mL of a water sample. The lead precipitate formed was filtered, washed and then dissolved in a few drops of nitric acid. The solution was then diluted to exactly 25.00 mL. This treated sample was analysed using atomic absorption spectrometry (AAS).
Lead ion standard solutions were similarly prepared and then analysed with the AAS.

Shown below is a calibration graph showing the absorbance values of the lead ion standard solutions and the treated unknown water sample.




The treated unknown water sample had an absorbance of 0.450.

(a) What is the concentration of lead ions in the treated unknown water sample in microgram/25 mL? **1**

.....

(b) What is the lead concentration of the original water sample in ppm?
Show your working. **2**

.....

.....

.....

**Question 28** (4 marks) **Marks**

Compare the uses of ethanol and water as solvents in terms of their molecular structures. **4**

……..

……..

……..

……..

……..

……..

……

……

……

**Question 29** (4 marks)

Unsaturated vegetable oils (molecules with double bonds) are reacted with hydrogen in the presence of a catalyst in the manufacture of margarine.

(a) Identify the type of reaction in the manufacturing process **1**

……..

(b) Write a balanced chemical equation for this type of reaction using ethene and hydrogen. **1**

(c) Outline a procedure you followed in class to compare the reactivity of an appropriate alkene with the corresponding alkane. Include the results of the determination. **2**

……

……

……

……

**Student Number ……..**

**Marks**

**Question 30** (5 marks)

Butyl ethanoate can be prepared in the school laboratory.

(a) Name the two reactants required to prepare butyl ethanoate and draw their structural formula. **2**

| | |
|---|---|
| | |
| …….. | …….. |

(b) State a common use for the class of compounds which includes butyl ethanoate. **1**

…….

(c) Outline reasons for refluxing the mixture. **2**

…….

…….

…….

…….

…….

**Marks**

**Question 31** (5 marks)

Evaluate the use of a named biopolymer produced related to its properties. **5**

……..

……

……

……

……

……

……

……

……

……

……

**Question 32** (3 marks)

Explain why the Haber process is a delicate balancing act involving reaction energy, reaction rate and equilibrium. **3**

……

……

……

……

……

……

……

……

**Student Number** ……

**Marks**

**Question 33** (3 marks)

Describe the formation of a coordinate covalent bond using $O_2$ and $O_3$ as an example, using Lewis electron dot structures. **3**

| | |
|---|---|
| | |

…….

…….

…….

…….

…….

*Go to the next page (page 23) for Section II - Industrial Chemistry Option*

**2013 JRAHS TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION**

# Chemistry

## Section II

**25 marks**
**Attempt question 34**
**Allow about 45 minutes for this section**

*Answer the question in a writing booklet. Extra writing booklets are available.*
*Show all relevant working in questions involving calculations.* **Marks**

**Question 34 Industrial Chemistry**

(a) Describe the process of extraction of sulfur from mineral deposits of sulfur. **4**

(b) Nitrogen dioxide is a brown gas which is manufactured from colourless nitric oxide by the following reaction.

$$2NO\ (g)\ +\ O_2\ (g) \rightleftharpoons 2NO_2\ (g)$$

(i) 10 mol of nitric oxide and 5 mol of oxygen gas were pumped into a 5 L container. The equilibrium concentration of nitrogen dioxide was 0.80 $molL^{-1}$.

Calculate the equilibrium constant for this reaction. **3**

(ii) Explain one condition that could be changed to increase the yield of nitrogen dioxide and identify the observable property that could be used to verify this shift in equilibrium. **2**

(c) You have carried out a first -hand investigation to observe the reaction of sulfuric acid acting as an oxidizing agent.
Outline the investigation performed and identify a risk associated with the investigation. **3**

(d) Brine is used in the production of sodium hydroxide and sodium carbonate.
Compare the use of brine in one method of sodium hydroxide production with the use of brine in the production of sodium carbonate and assess any environmental impacts of each method of production. **7**

(e) (i) Explain how an anionic detergent acts as an emulsifier with oil and water. **2**
(ii) Distinguish between an anionic and cationic detergent in terms of their chemical properties. **4**

*End of Trial HSC Examination*

# 2013

**TRIAL HSC EXAMINATION**

# Chemistry *ANSWER*

## General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Write your Student Number at the top of pages 11 12, 14, 16, 18, 20 and 22.
- Board-approved calculators may be used
- A data sheet and a Periodic Table are provided at the back of this paper.

**Total Marks – 100**

**Section I** Pages 2 – 22
**75 marks**

This section has two parts, Part A and Part B

Part A – 20 marks
•Attempt Questions 1- 20
•Allow about 35 minutes for this part

Part B – 55 marks
•Attempt Questions 21 – 33
•Allow about 1 hour and 40 minutes for this part

**Section II** Page 23

**25 marks**

•Attempt Question 34
•Allow about 45 minutes for this section

## Section I
**75 marks**

**Part A – 20 marks**
**Attempt Questions 1-20**
**Allow about 35 minutes for this part**

Use the multiple choice answer sheet on page 11.

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

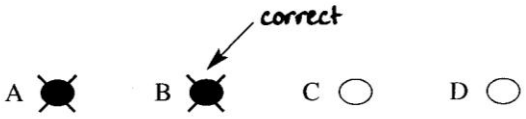
**Sample:** $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

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.




Mark your answers on the ANSWER grid on page 11.

---

**Multiple Choice**

Use the multiple – choice answer sheet for Questions 1 – 20 .

**1.** In the following nuclear reaction, what is the identity of $X$ ?

$$^{234}_{91}Pa \rightarrow {}^{234}_{92}U + X$$

(A) gamma radiation

(B) $^{4}_{2}He$

**(C)** $^{0}_{-1}e$

(D) $^{0}_{-1}H$

**2.** Which of the following is important in the nuclear stability of an atom ?

(A) the ratio of protons to electrons

**(B) the ratio of protons to neutrons**

(C) the atomic radius

(D) the atomic mass

**3.** A type of polymerisation reaction involves the release of a water molecule.
Which monomer is most likely to be involved in this reaction?

(A) ethane

(B) styrene

**(C) glucose**

(D) vinyl chloride

**4.** Expanded polystyrene can be produced by blowing gases through molten polystyrene and then allowing it to cool. A common use of this polystyrene is in the manufacture of protective foam packaging**.**

Which property of polystyrene makes it suitable for this use?

**(A) stiffness**

(B) transparency

(C) flexibility

(D) brittleness

**5.** Consider the following oxidation – reduction reaction:

$$I_2(aq) + 2\ S_2O_3^{2-}(aq) \rightarrow 2\ I^-(aq) + S_4O_6^{2-}(aq)$$

Which is the oxidant in the reaction?

**(A) $I_2$**

(B) $S_2O_3^{2-}$

(C) $I^-$

(D) $S_4O_6^{2-}$

**6.** Which list gives the species in the order of decreasing oxidising ability?

(A) $F_2$, $H^+$, $Ag^+$, $Cu^{2+}$

(B) $H_2O$, $Mg^{2+}$, $Al^{3+}$, $Mn^{2+}$

**(C) $MnO_4^-$, $Br_2$, $Ni^{2+}$, $Al^{3+}$**

(D) $Ca^{2+}$, $Mg^{2+}$, $Al^{3+}$, $Zn^{2+}$

**7.** Use the information to answer this question.

| *Indicator* | *Colour change* | *Transition pH* |
|---|---|---|
| Methyl orange | red to yellow | 3.1 – 4.4 |
| Bromothymol blue | yellow to blue | 6.2 – 7.6 |
| Phenolphthalein | colourless to pink | 8.3 – 10 |
| Litmus | red to blue | 5.1 – 8.0 |

If a few drops of the indicator are added separately to four flasks containing 0.00001 mol $L^{-1}$ HCl. What will be the colour of each solution containing the indicator?

| | *Methyl orange* | *Bromothymol Blue* | *Phenolphthalein* | *Litmus* |
|---|---|---|---|---|
| (A) | red | yellow | colourless | red |
| (B) | yellow | blue | colourless | blue |
| (C) | red | yellow | pink | red |
| **(D)** | **yellow** | **yellow** | **colourless** | **red** |

**8.** Given the following reactions of $SO_2$:

(i) $2\ SO_2(g) + O_2(g) \rightleftharpoons 2\ SO_3(g)$

(ii) $SO_2\ (g) + 2\ H_2O\ (l) \rightleftharpoons HSO_3^-\ (aq) + H_3O^+(aq)$

(iii) $SO_2\ (g) + CaO\ (s) \rightleftharpoons CaSO_3(s)$

Which reactions show the acidic nature of sulfur dioxide?

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

(B) (i) and (ii) only

(C) (i) and (iii) only

**(D) (ii) and (iii) only**

**9.** Airbags are safety features of modern cars that are designed to reduce the impact on passengers by rapid inflation in the event of a collision.

The main reaction is given by the following equation:

$$2NaN_3\ (s) \rightarrow 2Na\ (s) + 3N_2\ (g)$$

The sodium generated is eliminated in a subsequent reaction.

What mass of solid sodium azide ($NaN_3$) is theoretically required to inflate a 60.00 litre airbag with the volume being measured at 25 $^oC$ and 100 kPa?

**(A) 105 g**

(B) 236 g

(C) 53.0 g

(D) 118 g

**10.** Consider the following pairs of substances:

(i) $PO_4^{3-}$ and $H_2PO_4^-$

(ii) $O^{2-}$ and $OH^-$

(iii) $SO_3^{2-}$ and $H_2SO_3$

(iv) $NH_3$ and $NH_2^-$

Which are conjugate acid-base pair(s)?

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

(B) (i) and (iii) only

**(C) (ii) and (iv) only**

(D) (ii), (iii) and (iv) only

**11.** What is the pH of a mixture of 20.0 mL of 0.102 mol $L^{-1}$ barium hydroxide solution and 40.0 mL of 0.150 mol $L^{-1}$ hydrochloric acid diluted to a final volume of 100 mL?

(A) 2.715

**(B) 1.716**

(C) 11.285

(D) 12.284

**12.** Understanding the effect of trace elements on the health and well-being of plants and humans requires the use of instruments with certain characteristics.
What is the most important of these characteristics?

**(A) The instrument can detect low concentrations of the element.**

(B) The instrument is selective to the element even in the presence of impurities.

(C) The instrument is easy and quick to operate.

(D) The instrument can easily be automated.

**13.** A student needed to compare the strength of the three hypothetical acids $H_2A$, HB and HC .
The following suggestions were given by other students.

(i) Prepare 0.100 mol $L^{-1}$ solutions of each of $H_2A$, HB and HC and then titrate with 0.100 mol L NaOH solution.

(ii) Prepare 0.100 mol $L^{-1}$ solutions of each of $H_2A$, HB and HC and then measure the pH of each one with a pH meter.

(iii) Prepare a 0.0500 mol $L^{-1}$ $H_2A$, 0.100 mol $L^{-1}$ HB and 0.100 mol $L^{-1}$ HC and then titrate with 0.100 mol L NaOH solution.

(iv) Prepare a 0.0500 mol $L^{-1}$ $H_2A$, 0.100 mol $L^{-1}$ HB and HC and then measure the pH of each one with a pH meter.

Which of the suggestions should the student follow?

(A) (i)

**(B) (ii)**

(C) (iii)

(D) (iv)

**14.** While actually doing the experiment to compare the dissolved oxygen in several water samples, which controlled variable is the most important?

(A) The size of the bottle used to contain the samples should be the same.

(B) The intensity of light during the experiment should be different for all samples.

(C) The analysis time for each sample should be the same.

**(D) The temperature of the samples should all be the same.**

**15.** A student used the evaporation technique to determine the total dissolved solids in a water sample provided by her teacher.

She obtained the following results:

| | *Mass (g)* |
|---|---|
| Mass of empty evaporating basin | 300.00 |
| Mass of filter paper | 20.45 |
| Mass of evaporating basin + water sample | 1300.00 |
| Mass of filter paper + residue | 20.73 |
| Mass of evaporating basin + residue | 300.86 |

Which of the following are the correct results of the experiment?

| | *Total suspended solids (ppm)* | *Total dissolved solids (ppm)* |
|---|---|---|
| **(A)** | **280** | **860** |
| (B) | 860 | 280 |
| (C) | 0.28 | 0.86 |
| (D) | 0.86 | 0.28 |

**16**. Which would be an appropriate test to monitor the chemicals that may lead to eutrophication in waterways ?

(A) add barium chloride solution

**(B) add ammonium molybdate solution**

(C) add nitric acid

(D) add sodium hydroxide solution

**17.** Which is a correct sequence to purify and sanitise mass water supplies?

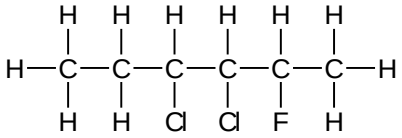
(A) add $Fe^{3+}$ → filter → add NaOH → add $Cl_2$

**(B) add NaOH → add $Fe^{3+}$ → filter → add $Cl_2$**

(C) filter → add NaOH → add $Fe^{3+}$ → add $Cl_2$

(D) add NaOH → add $Fe^{3+}$ → add $Cl_2$

**18.** What is the IUPAC name of the following compound?



(A) 5-fluoro-3,4-dichlorohexane

(B) 2-fluoro-3,4-dichlorohexane

(C) 3,4-dichloro-5-fluorohexane

**(D) 3,4-dichloro-2-fluorohexane**

**19.** Which of the following would most affect the concentration of ions in lakes?

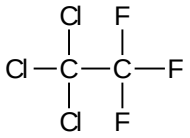
(A) the amount of rainfall

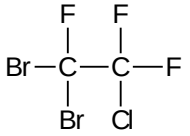
(B) the proximity to rubbish dumps

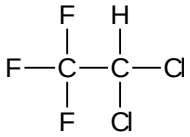
**(C) the pathway of rain to the waterbody**

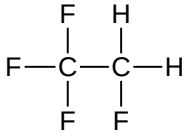
(D) the amount of human activity near the waterbody

**20**. Which compound has the highest ozone-depleting potential?

(A) 

**(B)** 

(C) 

(D) 

**Student Number** …….

**Section I** **Mark -----/20**

**Part A**

**Multiple Choice Answer Sheet**

| | | | | |
|---|---|---|---|---|
| **1**. | A ○ | B○ | C ● | D ○ |
| **2**. | A ○ | B ● | C ○ | D ○ |
| **3**. | A ○ | B ○ | C ● | D ○ |
| **4**. | A ● | B ○ | C ○ | D ○ |
| **5**. | A ● | B ○ | C ○ | D ○ |
| **6**. | A ○ | B ○ | C ● | D ○ |
| **7**. | A ○ | B ○ | C ○ | D ● |
| **8**. | A ○ | B ○ | C ○ | D ● |
| **9**. | A ● | B ○ | C ○ | D ○ |
| **10**. | A ○ | B ○ | C ● | D ○ |
| **11**. | A ○ | B ● | C ○ | D ○ |
| **12**. | A ● | B ○ | C ○ | D ○ |
| **13** | A ○ | B ● | C ○ | D ○ |
| **14**. | A ○ | B ○ | C ○ | D ● |
| **15**. | A ● | B ○ | C ○ | D ○ |
| **16**. | A ○ | B ● | C ○ | D ○ |
| **17**. | A ○ | B ● | C ○ | D ○ |
| **18**. | A ○ | B ○ | C ○ | D ● |
| **19**. | A ○ | B ○ | C ● | D ○ |
| **20**. | A ○ | B ● | C ○ | D ○ |

## Chemistry
## Section 1 (continued)

**Student Number ……..**

**Part B. 55 marks**
**Attempt questions 21 - 33**
**Allow about 1 hour and 40 minutes for this part**

- *Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.*
- *Show all relevant working in questions involving calculations.*

---

**Question 21**. (5 marks) **Marks**

Justify the development in technology from the *lead acid* or the *dry cell* to another battery with reference to their chemistry, cost and practicality. **5**

*Sample answer: Development from dry cell to the alkaline battery*

*Chemistry:*
*The dry cell has a Zn anode:* $Zn(s) \rightarrow Zn^{2+}(aq) + 2\ e^-$ *[*$e° = -1.04$ *volts]*
*and a graphite rod surrounded manganese(IV) oxide and carbon as cathode.:*
$2MnO_2(s) + 2\ e^- + 2NH_4Cl(aq) \rightarrow Mn_2O_3(s) + 2NH_3(aq) + H_2O(aq) + 2\ Cl^-$ *[*$e° \approx +.5$ *v]*

*With overall reaction:*
$Zn(s) + 2MnO_2(s) + 2NH_4Cl(aq) \rightarrow Mn_2O_3(s) + Zn(NH_3)_2Cl_2\ (aq) + H_2O(l)$

*The alkaline battery has a zinc anode also*
$Zn\ (s) + 2OH^-(aq) \rightarrow ZnO\ (s) + H_2O\ (l) + 2e-$
$2MnO_2\ (s) + H_2O\ (l) + 2e- \rightarrow Mn_2O_3\ (s) + 2OH-\ (aq)$

*The overall reaction:*
$Zn\ (s) + 2OH^-(aq)\ 2MnO_2\ (s) \rightarrow ZnO\ (s) + Mn_2O_3\ (s) + 2OH-\ (aq)$

*Practicality:*

*The dry cell or Leclange battery is cheap to produce but has a short shelf life since the zinc anode (the can) is attacked by the ammonium chloride. (see equation)The voltage falls during use due to a drop in electrolyte concentration around the cathode due to the lag in the diffusion of* $Mn_2O_3$ *away from the cathode. It is therefore suitable only for use with low demand equipment.*

*With the poor practicality of the dry cell, a "new" comparatively as cheap cell has been developed: the alkaline battery. The anode is made of zinc powder which allows for a greater surface area resulting in an increased rate of reaction and hence a greater rate of electron flow. The cathode is similar to the dry cell but the electrolyte is potassium hydroxide rather than ammonium chloride. This does not cause the extensive corrosion of the zinc anode.*
*Alkaline cells last longer, is more practical and only slightly more expensive than a dry cell, can be used in appliances which require intermittent bursts of high current such as a toy car. Therefore, the development of the alkaline battery is justified considering the deficiencies of the Leclange cell.*

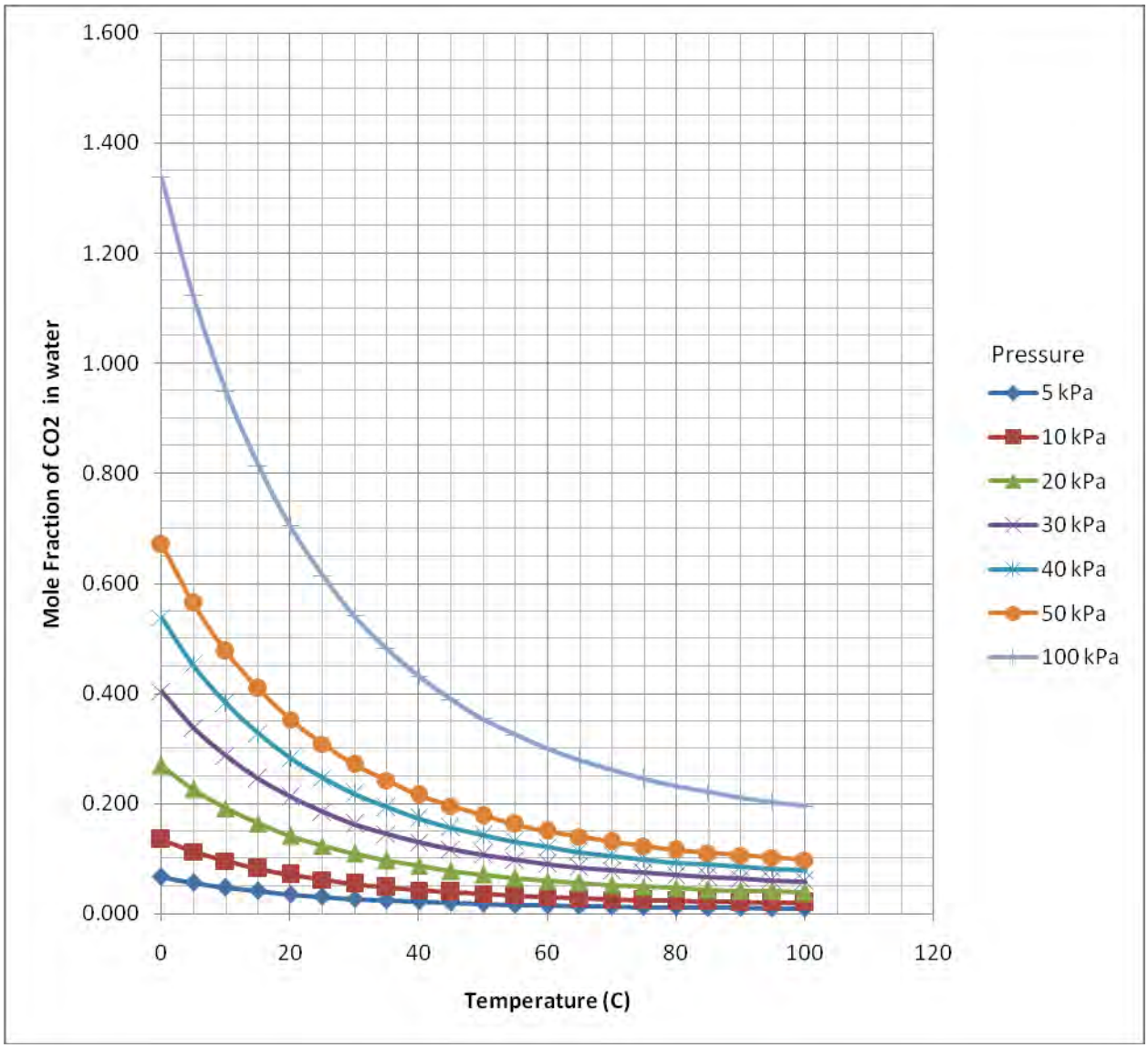
***O*utcomes: H3, H7,**

**Marking guidelines**

| *Criteria* | *Marks* |
|---|---|
| Overall reaction involved in both of the cells given | 2 |
| Only one of the cells given | 1 |
| Comparison of the cost of the two cells | 1 |
| Comparison of the practicality of the two cells | 1 |
| Justification summarizing chemistry, cost and practicality | 1 |

**Question 22** (8 marks)

Concentration can also be expressed in mole fraction. Mole fraction of a component is equal to the number of moles of the component over the total number of moles of the components of the mixture. Examine the graph of mole fraction of carbon dioxide (in a carbon dioxide - water mixture) against temperature at various pressures.




(a) Describe the variation of the solubility of carbon dioxide with temperature and with pressure. **2**

**Outcomes: H7, H8, H13**

*Sample answer:*
*The solubility of carbon dioxide in water decreases with increasing temperature and increases with increasing pressure.*

| *Criteria* | *Marks* |
|---|---|
| *Correct statement on the variation of the solubility with temperature and pressure* | *2* |
| *Correct statement on the variation of solubility with temperature or pressure* | *1* |

(b) Justify the variation of the solubility of carbon dioxide with pressure at 20 $^{o}$C using a relevant equation and Le Chatelier's principle. **3**

**Outcomes: H7, H8, H13**

*Sample answer:*

*Carbon dioxide dissolves in water:*

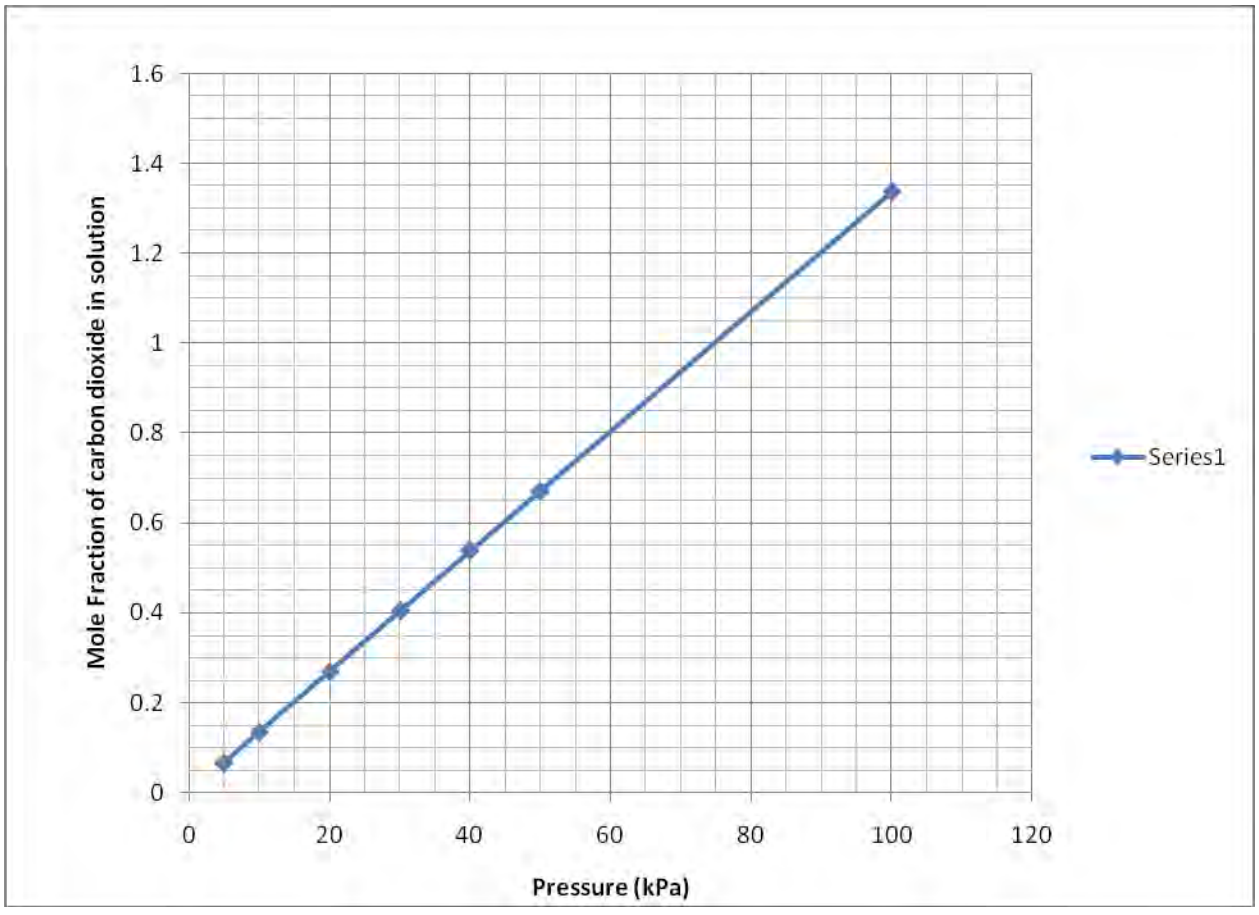
$CO_2(g) + 2\,H_2O(l) \rightleftharpoons HCO_3^-(aq) + H_3O^+(aq) \qquad \Delta H < 0$ *(exothermic)*

*According to Le Chatelier, increasing the pressure will favour the system that occupies less space and hence the one with less moles of gas. There is one mole of gas in the reactant side but none in the product side and hence, an increase in pressure will shift the equilibrium to the right.*

*Marking Guidelines*

| *Criteria* | *Marks* |
|---|---|
| *Thorough explanation using Le Chatelier's principle accompanied by a correct relevant equation* | 3 |
| *An explanation using Le Chatelier's principle with no equation* | 2 |
| *An explanation without using Le Chatelier's principle accompanied by an equation* | 2 |
| *An explanation making use of equilibrium principles without the use of equations* | 1 |

(c) Plot a graph of the mole fraction of carbon dioxide in solution versus pressure at a temperature of $0^oC$. **2**



Marking guidelines

| *Criteria* | *Marks* |
|---|---|
| *Correct data points* | *1* |
| *Line of best fit* | *1* |

(d) Use the graph to determine the mole fraction of carbon dioxide in the solution at a pressure of 80 kPa. **1**

*At $0^oC$ and 80 kPa, the mole fraction of carbon dioxide is 1.07.*

*Marking Guidelines*

| *Criteria* | *Mark* |
|---|---|
| *Correct reading of mole fraction, carryover error applies* | *1* |

**Question 23** (2 marks)

Write balanced equations to show the ionisation in water of a weak acid HA and a strong acid HB. **2**

**Outcomes: H13**

*Sample answer:*

$HA(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + A^-(aq)$

$HB(aq) + H_2O(l) \rightarrow H_3O^+(aq) + B^-(aq)$

| *Criteria* | *Marks* |
|---|---|
| *Correct equations with correct reaction arrow* | *2* |

**Question 24** (4 marks)

Identify a conjugate acid-base pair which can be used as an effective buffer.

Discuss how this buffer can maintain the pH when a base is added to it **4**

*Sample answer:*

*A conjugate acid-base pair that can be used as a buffer is the $CH_3COOH - CH_3COO^-$ pair. (1 mark)*

| *Criteria* | *Marks* |
|---|---|
| *Identification of a conjugate acid-base pair* | *1* |
| *Use of an equation to show the equilibrium* | *1* |
| *Use of Le Chatelier's principle to thoroughly explain the way the conjugate acid-base pair maintains pH when a base is added.* | *2* |
| *A cursory statement on how the buffer maintains pH* | *1* |

*Equilibrium equation of a buffer system:*

$CH_3COOH(aq) + H_2O(l) \rightleftharpoons CH_3COO^-(aq) + H_3O^+(aq)$

*When a base is added to the buffer, $H_3O^+$ ion combines with the added $OH^-$ neutralizing it. This depletes the $H_3O^+$ , in the product side, which according to Le Chatelier's principle is replenished by the equilibrium shifting to the right and ionising the acetic acid.*

**Outcomes: H7, H8, H9, H13**

**Question 25** (4 marks)

Describe the correct sequence of steps used in the first-hand investigation you performed in the laboratory to determine the concentration of vinegar by titration with standard sodium hydroxide solution. Include correct techniques and equipment which made this investigation valid. **4**

*Sample answer:*

- *A 25 - ml pipette was rinsed with vinegar.*
- *The pipette was used to measure out 25.00 mL of the vinegar into a 250- mL volumetric flask, previously rinsed with demineralised water.*
- *The volumetric flask was topped up with demineralised water to the mark (the fill line) with a fine dropper or wash bottle*
- *The solution was mixed well by inverting several times, keeping the thumb on the stopper of the volumetric flask.*
- *The 25 - ml pipette was rinsed several times with the diluted vinegar solution.*
- *Twenty five ( 25.00) mL of the diluted vinegar solution was transferred into a conical flask previously rinsed with demineralised water.*
- *A 50-mL burette was rinsed several times with the standard NaOH solution.*
- *The burette was filled with the NaOH solution ensuring that the level of solution was below the 0.00 mL graduation.*
- *It was ensured that there were no air bubbles in the burette tip before recording the initial burette reading.*
- *About two to three drops phenolphthalein indicator was added to the vinegar solution and mixed.*
- *The standard NaOH solution was added, with swirling from the burette, dropwise into the vinegar solution until the solution developed a permanent faint pink colour. The final burette reading was taken.*

*Marking guidelines*

| *Criteria* | *Marks* |
|---|---|
| *The instruction must include correct:*<br><br>*equipment - used properly*<br>*procedure sequentially ordered*<br>*rinsing protocol*<br>*indicator and the correct colour change.* | *4* |

**Outcomes: H8, H10, H13**

**Question 26** (5 marks)

A sample of lemon juice is to be analysed in the laboratory. A student took 25.00 mL of the juice and diluted it to 250.00 mL. Exactly 25.00 mL of the diluted lemon juice is titrated with standard 0.1045 mol $L^{-1}$ sodium hydroxide solution using phenolphthalein as the indicator. An average titre of 24.05 mL of sodium hydroxide solution was required
Assuming that the lemon juice contained only citric acid (molar mass = 192.1 g/mol), calculate the concentration in mol $L^{-1}$ of citric acid in the undiluted lemon juice. **5**

**Outcomes: H10, H11, H13**

*Sample answer:*

$H_3A + 3NaOH \rightarrow Na_3A + 3\,H_2O$ *(1 mark)*

*moles* $H_3A$ = *1/3 moles NaOH*
= $1/3(C \times V) = 1/3\ (0.1045)\ (\ 0.02405)$ *(1 mark)*
= $8.3774 \times 10^{-4}$

*conc of* $H_3A$ *(diluted)* $= (8.3774 \times 10^{-4})/0.0250 = 0.0335096$ *(1 mark)*

*conc of* $H_3A$ *(undiluted)* $= 0.0335096\ (250/25) = 0.3350$ *(1 mark)*

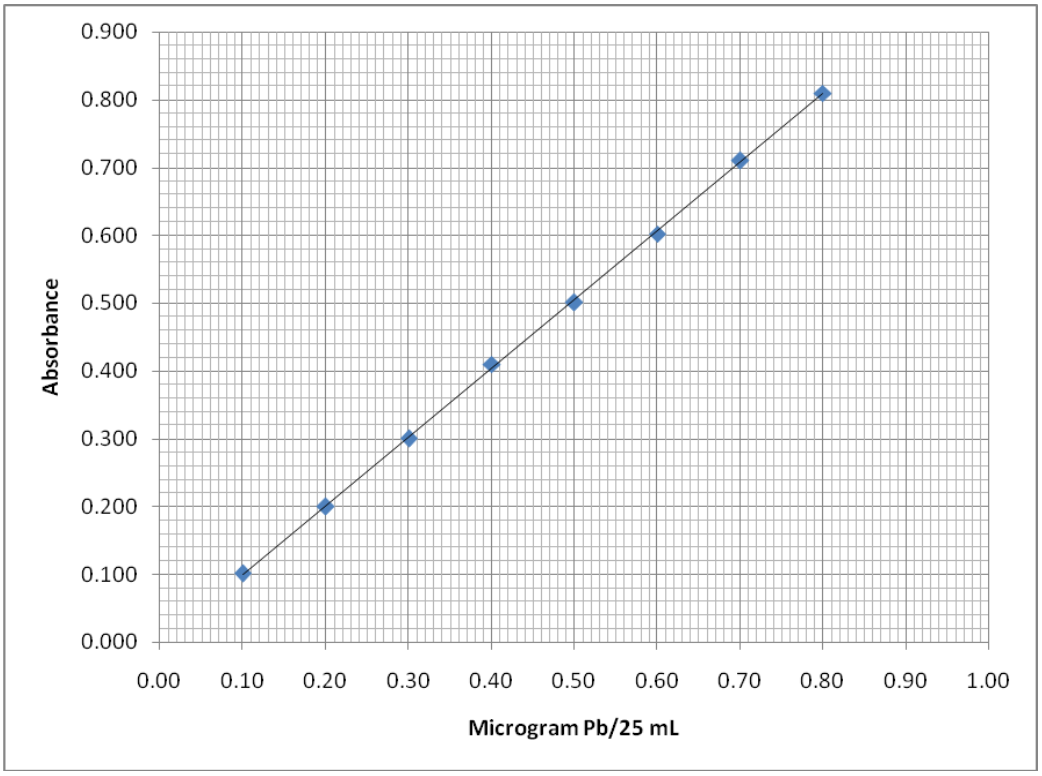
*significant figure (four)* *(1 mark)*

**Outcomes: H10, H11, H13**

**Question 27** (3 marks)

The lead ion precipitates with phosphate to form lead phosphate. An excess of a solution of sodium phosphate was added to exactly 100.00 mL of a water sample. The lead precipitate formed was filtered, washed and then dissolved in a few drops of nitric acid. The solution was then diluted to exactly 25.00 mL. This treated sample was analysed using atomic absorption spectrometry (AAS).
Lead ion standard solutions were similarly prepared and then analysed with the AAS.

Shown below is a calibration graph showing the absorbance values of the lead ion standard solutions and the treated unknown water sample.




The treated unknown water sample had an absorbance of 0.450.

(a) What is the concentration of lead ions in the treated unknown water sample in microgram/25 mL? **1**

**Outcomes: H13**

*The treated unknown water sample had a lead concentration of 0.450 microgram/25 mL*

(b) What is the lead concentration of the original water sample in ppm?
Show your working. **2**

*Sample answer:*

*The treated water sample had a concentration of 0.450 x $10^{-3}$ mg/ 25 mL or 0.018 mg/L*

*The original water sample had a concentration which was a quarter of the treated water sample hence:*

*Concentration of original = 0.018 x concentration factor= 0.018 x 25/100 = 4.5 x $10^{-3}$ $mgL^{-1}$*

*= 4.5 x $10^{-3}$ ppm*

**Question 28** (4 marks)

Compare the uses of ethanol and water as solvents in terms of their molecular structures. **4**

**Outcomes: H7**

*Sample Answer :*

*Ethanol has both a polar (-OH) and a non-polar($CH_3CH_2$ -) end thus suitable as a solvent for both polar and non-polar substances interacting via both hydrogen bonding and dispersion forces. Water is a polar molecule and hence, is suitable as a solvent in polar substances only interacting predominantly via hydrogen bonding and dipole –dipole interaction..*

**Marking Guidelines**

| *Criteria* | *Marks* |
|---|---|
| Comparison of both the structure and type of bonding present in both ethanol and water and its suitability as a solvent | 4 |
| One of the above missing | 3 |
| Two of the above missing | 2 |
| Three of the above missing | 1 |

**Question 29** (4 marks)

Unsaturated vegetable oils (molecules with double bonds) are reacted with hydrogen in the presence of a catalyst in the manufacture of margarine.

(a) Identify the type of reaction in the manufacturing process **1**

**Outcomes:H9**

*Sample Answer : Addition reaction*

**Marking guideline**

| *Criteria* | *Mark* |
|---|---|
| Correct identification of type of reaction | 1 |

(b) Write a balanced chemical equation for this type of reaction using ethene and hydrogen. **1**

$CH_2=CH_2 + H_2 \rightarrow CH_3CH_3$

**Marking Guidelines**

| *Criteria* | *Mark* |
|---|---|
| Correct balanced equation | 1 |

(c) Outline a procedure you followed in class to compare the reactivity of an appropriate alkene with the corresponding alkane. Include the results of the determination. **2**

*Sample Answer :*

*Add bromine water to equal quantities of the alkene and the corresponding alkane. The alkene will immediately decolourise the bromine water.*

**Marking Guidelines**

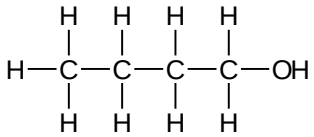
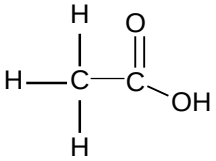
| *Criteria* | *Mark* |
|---|---|
| Correct test with result | 2 |
| Correct test or result | 1 |

**Question 30** (5 marks)

Butyl ethanoate can be prepared in the school laboratory.

(a) Name the two reactants required to prepare butyl ethanoate and draw their structural formula. **2**

*Sample answer:*

| | |
|---|---|
|  |  |
| *butan-1-ol* | *ethanoic acid* |

**Outcomes: H9, H8**

**Marking Guidelines**

| *Criteria* | *Mark* |
|---|---|
| 2 correct structural formula and names | 2 |
| One of the above missing | 1 |

(b) State a common use for the class of compounds which includes butyl ethanoate. **1**

*Sample Answer : flavouring for foods*

**Marking Guidelines**

| *Criteria* | *Mark* |
|---|---|

| | |
|---|---|
| Correct use of esters | 1 |

(c) Outline reasons for refluxing the mixture. **2**

*Sample Answer :*

*Allow reaction to proceed at a fast rate by heating without the loss of volatile liquids reactants and products*.

**Marking Guidelines**

| *Criteria* | *Marks* |
|---|---|
| Correct justification for refluxing | 2 |
| Brief description of refluxing | 1 |

**Marks**

**Question 31** (5 marks)

Evaluate the use of a named biopolymer produced related to its properties. **5**

**Outcome:H1**

*Sample Answer:*

*Biopol made with the organism Alcaligenes eutrophus is biocompatible and biodegradable thus suitable as use in medical sutures as it decomposes within the body thus no more surgery needed to remove it and suitable as packaging as it decomposes after a short period of time thus reducing the solid waste in landfills. The development and use of Biopol is of great significance and benefit to the environment and people who have to undergo surgery*.

**Marking Guidelines**

| *Criteria* | *Mark* |
|---|---|
| Evaluates the uses of a named biopolymer in relation to its properties | 5 |
| Discusses the uses of a named biopolymer in relation to its properties | 4 |
| Describes the uses of a named biopolymer in relation to its properties | 3 |
| Describes one use and one property of a named biopolymer | 2 |
| Identify one property OR one use of a named biopolymer | 1 |

**Question 32** (3 marks)

Explain why the Haber process is a delicate balancing act involving reaction energy, reaction rate and equilibrium. **3**

**Outcome:H8**

*Sample Answer:*

*The reaction rate needs a high enough temperature so that the particles have enough energy for successful collisions to occur, but the reaction is exothermic so too high a temperature will cause the reverse reaction to occur thus reduce the yield of ammonia. Thus a compromise temperature of 400-500$^0$C is required to maximise yield at a reasonable rate of reaction.*

**Marking guidelines**

| *Criteria* | *Mark* |
|---|---|
| Thorough explanation of the need to balance reaction rate, energy requirements and equilibrium | 3 |
| Description of need to balance reaction rate and energy needs | 2 |
| Identification of one factor which relates to reaction rate, energy requirements and equilibrium | 1 |

…….

…….

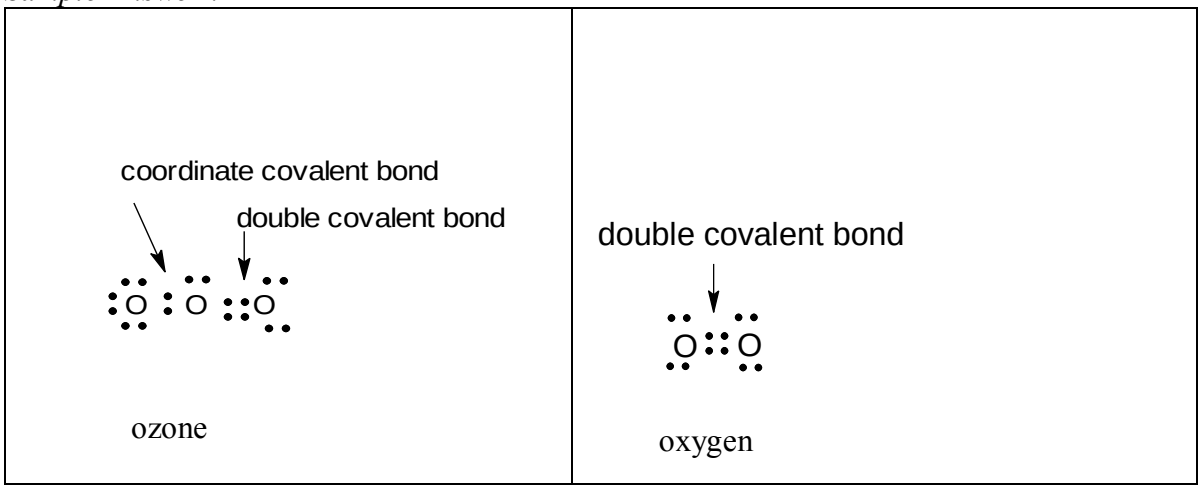
…….

**Question 33** (3 marks)

Describe the formation of a coordinate covalent bond using $O_2$ and $O_3$ as an example, using Lewis electron dot structures. **3**

**Outcome:H6**

*Sample Answer :*




*A coordinate covalent bond occurs where one atom shares two electrons with another atom. This type of bond occurs in ozone where there is one double bond and one coordinate covalent bond but not in oxygen where there is only one double bond.*

*Correct Lewis electron dot diagrams for each molecule*

**Marking Guidelines**

| *Criteria* | *Mark* |
|---|---|
| Correct definition and description of coordinate covalent bond present in ozone but not in oxygen with the correct Lewis dot diagrams | 3 |

| | |
|---|---|
| One of the above missing | 2 |
| Identification of one of the above | 1 |

**2013 JRAHS TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION**

# Chemistry

## Section II

**25 marks**
**Attempt question 34**
**Allow about 45 minutes for this section**

*Answer the question in a writing booklet. Extra writing booklets are available.*
*Show all relevant working in questions involving calculations.* **Marks**

**Question 34 Industrial Chemistry**

(a) Describe the process of extraction of sulfur from mineral deposits of sulfur. **4**

(b) Nitrogen dioxide is a brown gas which is manufactured from colourless nitric oxide by the following reaction.

$$2NO\ (g)\ +\ O_2\ (g) \rightleftharpoons 2NO_2\ (g)$$

(i) 10 mol of nitric oxide and 5 mol of oxygen gas were pumped into a 5 L container. The equilibrium concentration of nitrogen dioxide was 0.80 $molL^{-1}$.

Calculate the equilibrium constant for this reaction. **3**

(ii) Explain one condition that could be changed to increase the yield of nitrogen dioxide and identify the observable property that could be used to verify this shift in equilibrium. **2**

(c) You have carried out a first -hand investigation to observe the reaction of sulfuric acid acting as an oxidizing agent.
Outline the investigation performed and identify a risk associated with the investigation. **3**

(d) Brine is used in the production of sodium hydroxide and sodium carbonate.
Compare the use of brine in one method of sodium hydroxide production with the use of brine in the production of sodium carbonate and assess any environmental impacts of each method of production. **7**

(e) (i) Explain how an anionic detergent acts as an emulsifier with oil and water. **2**

(ii) Distinguish between an anionic and cationic detergent in terms of their chemical properties. **4**

**Answers: OPTION**

(a) Describe the process of extraction of sulfur from mineral deposits of sulfur. **4**

*Sample Answer*
*Sulfur is extracted from mineral deposits using the Frasch process.*
*A hole is drilled through the overlying rock and 3 pipes are inserted into the drill hole. The outer pipes contain superheated steam which is pumped down to the deposit where it melts the sulfur, as the melting point of sulfur is quite low. Air is pumped down the second pipe to force the sulfur in water emulsion back out to the surface through the third pipe. As the water cools the sulfur solidifies and is filtered out.*

| ***Marking Criteria*** | ***Marks*** |
|---|---|
| • Describes the process and identifies it as the Frasch process | 4 |
| • Outlines the process and identifies it as the Frasch process OR<br>• Describes the process but fails to identify it as the Frasch process | 3 |
| • Outlines the process | 2 |
| • Identifies the Frasch process OR<br>• Identifies a property of sulfur | 1 |

**Outcomes : H3, H4**

(b) Nitrogen dioxide is a brown gas which is manufactured from colourless nitric oxide by the following reaction.

$$2NO\ (g) + O_2\ (g) \rightleftharpoons 2NO_2\ (g)$$

(i) 10 mol of nitric oxide and 5 mol of oxygen gas were pumped into a 5 L container. The equilibrium concentration of nitrogen dioxide was 0.80 $molL^{-1}$. Calculate the equilibrium constant for this reaction . **3**

*Sample answer*

| | $2NO\ (g)$ | $+\ O_2\ (g)$ | $\rightleftharpoons\ 2NO_2\ (g)$ |
|---|---|---|---|
| *Initial* | *10/5* | *5/5* | |
| *Used* | *0.80* | *0.40* | |
| *Equilibrium* | *1.2* | *0.60* | *0.80* |

$K = [NO_2]^2 / [NO]^2 \times [O_2]$
$= (0.80)^2 / (1.2)^2 \times 0.6$
$= 0.74$

| ***Marking Criteria*** | ***Marks*** |
|---|---|
| • Correct calculation with all relevant working | 3 |
| • Some relevant working | 2 |

| | |
|---|---|
| • K expression OR<br>• One correct calculation | 1 |

**Outcomes : H10**

(ii) Explain one condition that could be changed to increase the yield of nitrogen dioxide and identify the observable property that could be used to verify this shift in equilibrium. **2**

*Sample answer*

*Increasing the pressure would favour the forward reaction as it has fewer gas molecules (3:2) therefore shifting equilibrium to the side that opposes the change (Le Chatelier). The colour would change from colourless to brown.*

| ***Marking Criteria*** | ***Marks*** |
|---|---|
| • Explanation of correct shift and correct colour change | 2 |
| • Explanation of correct shift OR<br>• Correct colour change OR<br>• Correct colour change for incorrect shift | 1 |

**Outcomes : H8**

(c) You have carried out a first -hand investigation to observe the reaction of sulfuric acid acting as an oxidizing agent.
Outline the investigation performed and identify a risk associated with the investigation. **3**

*Sample answer*

*We reacted dilute sulfuric acid with Zn metal and a gas was liberated. We performed the pop teats to identify it as hydrogen. The Zn metal was oxidized and the hydrogen ions were reduced.*
*$Zn\ (s) + H_2SO_4 \rightarrow Zn\ SO_4 + H_2\ (g)$*
*A risk is the handling of sulfuric acid as it is corrosive.*

| ***Marking Criteria*** | ***Marks*** |
|---|---|
| • Outlines valid investigation and identifies a risk | 3 |
| • Outlines a valid investigation OR<br>• Identifies an investigation and a risk | 2 |
| • Identifies a risk OR<br>• Identifies a reaction of sulfuric acid | 1 |

**Outcomes : H8**

(d) Brine is used in the production of sodium hydroxide and sodium carbonate.
Compare the use of brine in one method of sodium hydroxide production with the use of brine in the production method of sodium carbonate and assess any environmental impacts of the production methods. **7**

*Sample Answer*

*Both the production of NaOH and $Na_2CO_3$ start with concentrated brine, NaCl.*
*The brine in NaOH production undergoes electrolysis to produce chlorine gas and NaOH. In the mercury process of NaOH production, chloride ions from the brine are oxidized at the graphite anode to produce chlorine gas.*

$2Cl^- \rightarrow Cl_2\,(g) + 2e^-$

*Sodium ions are reduced at the flowing mercury cathode to create an amalgam which flows into a separate compartment where it is sprayed with water to produce NaOH.*

$2Na + 2H_2O \rightarrow 2NaOH + H_2\,(g)$

*The brine in sodium carbonate production supplies the sodium ions and creates an ammoniated brine from which sodium bicarbonate crystalises.*

*The overall reaction for the Solvay process is*

$2NaCl + CaCO_3 \rightarrow Na_2CO_3 + CaCl_2$

*The brine must first be purified to remove other cations e.g $Ca^{2+}$ ions. This is done through precipitation reactions. The brine is then pumped to the Solvay Tower where it reacts with carbon dioxide to produce sodium bicarbonate.*

$NH_3 + NaCl + H_2O + CO_2 \rightarrow NaHCO_3 + NH_4Cl$

*The sodium bicarbonate is then decomposed with heat to make sodium carbonate.*

*An environmental impact of the mercury process is the loss of mercury to the environment.*
*Mercury is toxic and can bioaccumulate in organisms and cause neurological damage.*

*Assessment :*
*It is a dangerous process for organisms in the environment and has been phased out of use.*

*An environmental impact of the Solvay process can be the disposal of waste calcium chloride. Although some can be used commercially most is waste. If near the ocean the salts can be pumped in and will have a minimum effect on the environment however, further away from the ocean, the release of excess calcium chloride into waterways would cause an increase in salinity which could kill aquatic organisms and plants.*
*Assessment:*
*This can cause serious damage to ecosystems and measures such as evaporating ponds and land disposal are necessary to avoid the consequences of river release of calcium chloride.*

| *Marking Criteria* | *Marks* |
|---|---|
| • Fully describes the use of brine in an identified method of production of NaOH and $Na_2CO_3$ production AND<br>• Includes relevant chemical equations AND<br>• Describes an environmental impact of each process AND<br>• Makes an assessment on one of the impacts AND<br>• Responds in a cohesive and coherent manner | 7 |
| • Describes the use of brine in an identified method of production of NaOH and $Na_2CO_3$ production AND<br>• Includes relevant chemical equations AND<br>• Describes an environmental impact of each process described<br>• OR missing an equation or environmental impact but has an assessment | 6 |
| • Describes the use of brine in an identified method of production of NaOH and $Na_2CO_3$ production AND/OR<br>• Includes relevant chemical equations AND/OR<br>• Describes an environmental impact of each process. | 5 |
| • Outlines the use of brine in one method of production of NaOH and $Na_2CO_3$ production AND<br>• Outlines an environmental impact of each process. OR<br>• Includes a relevant equation | 4 |
| • Outlines the use of brine in one method of production of NaOH or $Na_2CO_3$ production AND<br>• Outlines the environmental impacts of the process. OR<br>• Outlines the use of brine in one method of production of NaOH and $Na_2CO_3$ production | 3 |
| • Outlines the use of brine in the production of NaOH or $Na_2CO_3$ production OR<br>• Outlines the environmental impacts associated with NaOH production or $Na_2CO_3$ | 2 |
| • One correct statement about the production or environmental impact of either process | 1 |

**Outcomes : H3,H4,H8,H13**

(e) (i) Explain how an anionic detergent acts as an emulsifier with oil and water. **2**

*Sample answer*

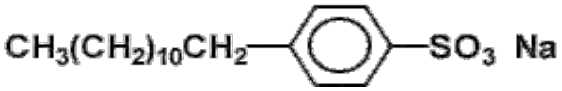
*The non-polar alkyl tail of the detergent forms dispersion forces with the non-polar oil and the polar benzene sulfonate head of the detergent forms hydrogen bonds with water. The tails are embedded in the oil and the negatively charged heads on the outside of the oil droplet repel other droplets keeping them suspended in the water forming an emulsion.*

| *Marking Criteria* | *Marks* |
|---|---|
| • Correctly explains the emulsification of oil and water by detergent. Must describe the emulsion | 2 |
| • Outlines the emulsification of oil and water by detergent | 1 |

**Outcomes : H9**

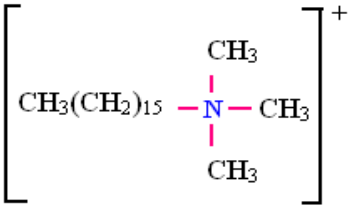
(ii) Distinguish between an anionic and cationic detergent in terms of their chemical properties.

*Sample answer*
*Anionic detergents are alkyl benzene sulfonates with a negatively charged end.*



*the negative end on the ion allows it to strip oil from negative surfaces and is a strong cleaning agent*

*Cationic detergents detergents are positively charged with a modified ammonium ion on the end of long alkyl chain.*



*The positive end of the ion allows it to attach itself to negative surfaces creating a soft finish to the cleaning eg in conditioners and fabric softeners. OR*
*Biocidal ( a chemical property)*

| ***Marking Criteria*** | ***Marks*** |
|---|---|
| • Describes each detergent (must have the full correct structure) and gives a chemical property that distinguishes between the two. | 4 |
| • Describes the chemical properties of both detergents (structures not complete) | 3 |
| • Describes one detergent correctly OR<br>• Outlines the chemical properties of each detergent | 2 |
| • Identifies anionic with a negative end and cationic with a positive end | 1 |

**Outcomes : H4,H9**

*End of Trial HSC*